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NEARBY GROUPS OF GALAXIES

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CHAPTER 17

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CONTENTS

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CHAPTER 17.

NEARBY GROUPS OF GALAXIES

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17.1. Definition of a Group.

Binary galaxies discussed in Chapter 16 are a special case of multiplicity and clustering among galaxies. Large-scale clustering is discussed in Chapter 18. The present chapter discusses multiple systems: groups, clusters, and clouds of intermediate size ($D \approx 1$-3 Mpc) and population ($n \approx 10$-100). Such systems can be identified and best studied individually in our immediate neighborhood ($\Delta < 20$ Mpc). The nearer galaxies used in the calibration of the distance scale and in assessing the detailed properties of galaxies are generally members of nearby groups.

By "group" is meant a number $n > 2$ of distinct galaxies that are bound gravitationally for periods of the order of 10^9 years or greater (star cluster analogy) or perhaps are genetically related as products of a common explosive formative event during the past 10^9 years or so even though they may not be gravitationally bound at present (stellar association analogy).

These concepts, however, are not suitable as operational definitions. In practice a "group" will be a "small" number of galaxies, say $n \approx 10$ brighter than $M = -16$ (perhaps of a specified class only, either elliptical and lenticular, or spiral and irregular) occupying a volume of space V in which the average density $\rho_n = n/V$, say $\rho_n \approx 10$

per Mpc^3, is at least one order-of-magnitude greater than the average density $\overline{\rho_1}$ in a surrounding volume of space of diameter one order-of-magnitude greater than that of the group. In other words the significant factor is the contrast with the surrounding field, not the absolute densities or numbers. Note that number density is considered, not mass density (which would exclude the equivalent of stellar associations).

Space density, however, is not an observable and the basic observational criterion of clustering is surface density in the apparent distribution. Since dwarf galaxies (dE, dIm) are inconspicuous or invisible in all but the nearest groups, a group is first identified by its brightest members. Further criteria of group membership include a small velocity range and a general similarity of morphological types, apparent magnitudes and diameters.

17.2. Census of Nearby Groups.

In this Chapter "nearby" is defined by the condition $m - M < 31.2$ (corresponding to $\Delta < 17$ Mpc and $\overline{V} < 3000$ km/sec). This condition excludes the nearest large clusters of the Coma type and implies for the brightest member galaxies an apparent magnitude $m_G < 13$ corresponding to the nominal limit of the Harvard census of 1250 galaxies (Shapley-Ames 1932) and to the estimated 50 per cent completeness level of the new Reference Catalogue of Bright Galaxies of 2600 galaxies (G. and A. de Vaucouleurs 1964).

In order to make the census of nearby groups as complete as possible the following procedure was adopted

1) A list was prepared of all galaxy groupings previously described in the literature as "groups" or "clusters" and which have at least one member in the <u>Reference Catalogue</u>;

2) A finding list of all possible pairs, multiple galaxies or groups of bright galaxies was extracted from the <u>Reference Catalogue</u> by inspection of listings by coordinates and of distribution maps;

3) All recognized clusters (Coma, Perseus, etc.) were rejected from further discussion;

4) A tabulation of galaxy types, magnitudes, diameters and velocities was prepared for all other groupings which appeared likely to fall in the range defined above;

5) The relative distance moduli of the nearest groups (m-M < 30) were derived from all available secondary distance criteria (luminosity class, brightest stars, HII regions), using the distance moduli of the Local Group members derived from primary criteria (cepheids, novae, RR Lyrae) for absolute calibration, on the distance scale defined by Sandage (1961) and by van den Bergh in Chapter 15 of this volume;

6) Using the nearest groups as standards, tertiary distance indicators (luminosity and diameter) were calibrated as a function of galaxy type and rank and used to compute photometric and geometric moduli ~~to~~ of all other identified groups and clusters.

This procedure appears to be successful for all groups including S and I systems, but the scarcity of nearby groups of E and L systems prevents a direct calibration of these classes by secondary criteria, the indirect calibration by means of groups including both S, I and E, L systems is somewhat uncertain because of the high degree of segregation.

17.3. Distance Moduli.

Distance moduli were derived from primary and secondary indicators for a dozen nearby groups (Sculptor, M81, M51-101, CVn I, CVn II, M66, M96, N3190, N1023, etc.) including a total of 68 galaxies (M_G < -16 with known magnitudes and diameters in the standard systems. From this sample the following relations were derived for the absolute magnitude $M_G(n)$ and linear diameter $D(n)$ of the n-th brightest or largest galaxy in a group:

a. Magnitudes: $\mu = B(0) - M_G(n)$,

where B(0) is the B magnitude in the standard system of the Reference Catalogue, and $M_G(n) = M_o + 0.5\,n \quad (n \leq 5)$

with M_o = -20.0 for types E, L and S0 to S7 (i.e. S0/a to Sd),

= -19.5 for types S8, S9 (Sdm, Sm)

= -19.0 for type I9 (= Im).

The luminosity classes of spirals (van den Bergh 1960a) were also used where available with the following calibration (after van den Bergh, but adjusted to fit the latest data on the Local Group)

Class	I	I-II	II	II-III	III	III-IV	IV	IV-V	V
$\mathcal{L}$	1	2	3	4	5	6	7	8	9
$-M_G$	19.95	19.45	18.95	18.45	18.00	17.55	16.85	15.65	14.00

here again M_G is on the B(0) system.

N.B.: The total (asymptotic) magnitude is about 0.5 mag. less than B(0) depending on galaxy type (0.67 at type E, 0.33 at Im).

b. Diameters: $\mu = 27.68 + 5[\log D(n) - \log D(0)]$

where D(0) is the "face-on" diameter (in minutes of arc) in the standard system of the Reference Catalogue and $\log D(n) = \gamma_o - 0.10\,n$ (D in kpc, $n \leq 5$)

with γ_0 =	1.10	1.15	1.20	1.25	1.30	1.35	1.30	1.20
for $\mathcal{T}$ =	E	L	S0,1	S2,3	S4,5	S6,7	S8,9	I9

c. Sampling Correction: The groups used in the calibration are all small nearby groups with the following mean luminosity function:

M_G <	-19	-18	-17	-16
$\bar{N}(M_G)$	1.3	3.2	4.5	6.4

In larger groups, a size of sample correction is required since the larger the sample (population of group) the greater the probability of occurence of outstanding objects. The correction was determined through a comparison of the distance moduli derived for the Virgo Cluster taken as a whole or divided into smaller groups and sub-groups. If N_{18} is the number of galaxies having $M_G < -18$ in a group the correction to the modulus derived as explained in sections (a, b) above is

$$\Delta\mu = 2.0\ (\log N_{18} - 0.5)$$

d. Absorption Correction: Finally, photometric apparent moduli must be corrected for galactic absorption: $\mu_0 = \mu - A_B$; the correction was computed through the following equation derived by G. Malik from a new analysis of the Mount Wilson (Hubble's) counts:

$$A_B = A_1[1 + \frac{P}{B_1} \cos \ell + \frac{Q}{B_1} \cos 3\ell] \operatorname{cosec} |b - b_o(\ell)| \qquad (1)$$

where

$$b_o(\ell) = -0^\circ\!.25 + 1^\circ\!.7 \sin \ell + 1^\circ\!.0 \cos 3\ell \qquad (2)$$

and

	B_1	P	Q
N.G.H.	-0.188	-0.024	-0.004
S.G.H.	-0.204	-0.010	+0.032

The value used here for the optical half-thickness of the Galaxy, A_1 = 0.2 mag., applies only to a sample selected by apparent brightness,

it agrees well with color excess data (Holmberg 1958, de Vaucouleurs 1961a) down to the lowest galactic latitudes. (The unbiased value derived from Hubble's counts of faint galaxies is much larger, about A_1 = 0.48 mag., and in agreement with the results from the Lick counts described by Shane in Chapter 19).

17.4. Local Group.

It is often arbitrarily defined by a radius Δ = 1.0 Mpc from the Galaxy or, possibly, from the center of gravity of the Galaxy and M31, the two giant members. The Local Group includes two average spirals M33 and the Large Magellanic Cloud, over a half dozen dwarf magellanic irregulars (Small Cloud, N6822, IC 1613, IC 10, A2359, A 0956, A 0957, A 1009) and at least a dozen dwarf ellipticals (N 147, 185, 205, 221, A 0058, A 0237, A 1003, A 1006, A 1111, A 1127, A 1719, and other poorly known globular-like systems). Detailed information on the Local Group members is given in Tables 1a and 1b.

Additional S, I members hidden by galactic absorption might be discovered by their 21 cm emission. An apparent obscuration patch in Microscopium has been suggested as a possible intergalactic dark cloud within the Local Group (Hoffmeister 1962)

The distance moduli in Table 1b based on primary and secondary criteria (de Vaucouleurs 1955, van den Bergh 1960c, Sandage 1961, and Chapter 15 by van den Bergh) define the distance scale used in the present chapter

Figure 1 shows the apparent distribution of Local Group members in supergalactic coordinates There is only a slight concentration

toward the supergalactic equator as might be expected for very close objects.

Figure 2 is a map of the Local Group projected onto the supergalactic plane; note the strong "sub-clustering" tendency around two dominant multiplets (Galaxy-LMC-SMC triplet + dE satellites; M31-M33 pair + dE satellites). The overall diameter of the group is about 2.0 x 1.5 Mpc in the SG plane and 1.0 Mpc at right angles to it (0.[illegible] Mpc if A 0956, A 1009 are not members).

The Local Group is a typical loose group without central condensation. Except for the satellite dE systems it includes only spirals of type Sb and later and magellanic irregulars. The distribution of total absolute magnitudes (assuming $M_B = -18.8$ for the Galaxy, after Gyllenberg 1937) is as follows:

$M_T(B) \leq$		-20		-19		-18		-17		-16		-15		-14
n	1		0		3		1		1		2		4	
N		1		1		4		5		6		8		12

for a total of 12 members brighter than $M_T(B) = -14$; another dozen or more with less precisely known magnitudes are in the range -14 to -10. For further discussion of dwarfs in the Local Group see section 17.8.

The total mass (of galaxies) in the group $\mathfrak{M}_T \sim 6.5 \times 10^{11} \odot$ is not much larger than the combined masses of M31 and the Galaxy (5×10^{11}); M33 and the magellanic irregulars LMC, SMC, N6822, IC 10, etc. add only thirty per cent and the combined mass of the ellipticals is probably negligible ($<10^{10} \odot$) even if their space density is as high as 100 per Mpc^3. For a volume of the order of 2 Mpc^3, the smoothed mean density is $\overline{\rho_G} \approx 0.5 \times 10^{-28}$ gcm^{-3}. The total absolute

magnitude of the group is $M_T \approx -20.9$ (B) or -21.6 (V) with some uncertainity due to the indirect estimate for our Galaxy; the average mass-luminosity ratio is $f = \mathfrak{M}_T/\mathfrak{L} \approx 20$ (B and V). The total mass of neutral hydrogen in galaxies is $\mathfrak{M}_H \approx 1.0 \times 10^{10} \odot$ and the hydrogen/total mass and hydrogen/luminosity ratios are $h = \mathfrak{M}_H/\mathfrak{M}_T \approx 0.01_5$ and $g \approx \mathfrak{M}_H/\mathfrak{L}_B \approx 0.3$.

17.5. The Nearer Groups within 10 Megaparsecs.

The nearer groups are the groups whose distance moduli $\mu_0 \leq 30$ ($\Delta \leq 10$ Mpc) can be derived from secondary distance criteria (HII regions, bright stars, luminosity class). These groups in turn serve to calibrate the tertiary distance criteria (magnitudes, diameters) which are used to derive the distances of more distant groups or of southern hemisphere groups for which the secondary criteria are still missing. The apparent distribution of the nearer groups in supergalactic coordinates is shown in Fig. 3. Available data on each group taken mainly from the Reference Catalogue of Bright Galaxies (abbreviated B.G.C.) are presented in tabular form (Tables 2 and 3). A brief description of individual groups follows.

G1. Sculptor Group ($\mu_0 = 26.9$, $\Delta = 2.4$, $V_0 = 142$). This nearest of all nearby groups is a loose association of six or seven late-type spirals Sc to Sm (NGC 45, 55, 247, 253, 300, 7793, and perhaps IC 5332) distributed at the rim of a 20° ring near the South Galactic Pole (de Vaucouleurs 1956a, 1959).

The fainter, smaller member NGC 45 has also the largest velocity

and it may be on the far side of the group. If the group had a depth along the line of sight equal to its apparent diameter the individual distance moduli could have a range of up to $\Delta\mu = 0.7$ mag. from, say, 26.7 to 27.4. However the nearly circular outline suggests a flat structure seen face on. The group has not merely no central concentration, but actually an empty region in its center. This peculiar structure is apparent in several other loose groups of spirals. It suggests the possibility that such groups are the galactic equivalent of old expanding stellar associations (de Vaucouleurs 1959).

The maximum dimensions of the group 25° x 20° = 1.0 x 0.8 Mpc (or 20° x 20° if IC 5332 is excluded) are of the same order as the Local Group limited to its brighter members. The velocity range is about 600 km/sec (-129 to +489) or 330 (-129 to +197) if N45 is excluded. Detailed photometry, continuum and HI radio data, optical and radio rotation curves and mass estimates are available for several of the brighter members (de Vaucouleurs 1961b, de Vaucouleurs and Page 1962, Epstein 1964, Robinson and van Damme 1964, and Chapter 3 of this volume). A HI cloud sharing the velocity of NGC 300 has been reported by Shobbrook (unpublished) in a position several degrees from the galaxy where no optical luminosity can be seen.

G2. <u>M81 Group</u> ($\mu_0 = 27.0$, $\Delta = 2.5$, $V_0 = 160$). This well-known group centered on the M81-82 pair in Ursa Major includes several late-type spirals and dwarf irregular satellites: NGC 2976, NGC 3077, IC 2574 (= DDO 81), A 0936 (Ho I = DDO 63) and A 0814 (Ho II = DDO 50) (Holmberg 1950). Several large nearby spirals including NGC 2366, 2403 and possibly 4236 have comparably low velocities and may be outlying members of the group. NGC 2403, 2366, A 0814 and two or three

other dwarfs (DDO 44, 51, 53) may in fact form a sub-group in a larger cloud extending into Camelopardalis and including also the low-latitude, obscured group formed by NGC 1560, 1569, IC 342, IC 356 and possibly several dwarfs (DDO 33, 38, 39). This cloud may be interrupted by the galactic absorption belt. The overall dimensions of the cloud 40° x 20° = 1.8 x 0.9 Mpc are typical of these formations (compare UMa I, Virgo II, Leo II, etc.); the restricted M81 group is only 13° x 7° = 0.6 x 0.3 Mpc or somewhat smaller than the Local Group.

Because of the large range of galactic latitudes covered by the UMa-Cam Cloud the apparent modulus varies from 27.3 (A = 0.3 mag.) for M81 to 28.3 (A = 1.2 mag.) for IC 342. The velocity range is about 350 km/sec (-26 to +322).

The M81 group includes two examples of the rare I0 (or Irr II) galaxy type, NGC 3034 and NGC 3077. Both display well-known optical and/or radio peculiarities (see B.G.C. for references). Radio continuum and HI emission, optical and radio rotation curves and mass estimates are available for several of the brighter members (Epstein 1964, Heeschen and Wade 1964). (See Chapter 3 of this volume by E. and G. Burbidge for detailed references on rotation curves).

G3. Canes Venatici I Cloud (μ_0 = 27.9, Δ = 3.8, V_0 = 342). A loose cloud of low-velocity objects may be isolated in the foreground of several more distant, overlapping groups and clouds in the UMa-CVn-Coma area. This whole region is described as the CVn cluster or M94 group by van den Bergh (1960d), who points out that many dwarfs are concentrated in this area (van den Bergh 1959); Sersic (1960) describes a subset as the UMa I group and another as the UMa II group (both of which, however, are all within the boundaries of CVn). A detailed comparison of luminosities, diameters, velocities, HII regions and brightest stars supports the latter interpretation. After much searching

and with some hesitation in borderline cases the following objects were isolated as members of the foreground CVn I cloud (or restricted M94 group): NGC 4136, 4150, 4214, 4244, 4258, 4395, 4449, 4736 (M94) IC 4182, A 1157 (= DDO 105), and possibly NGC 4826 (M64). Other possible dwarf members include DDO 39, 125, 126, 129, 133, 141, 143, 156. All members are spirals of type Sb or later and magellanic irregulars. The overall dimensions of the cloud are 28° x 14° = 1.9 x 0.9 Mpc (including N4826) and the velocity range about 300 km/sec (236 to 530). Radio continuum and HI emission has been detected in several members including NGC 4214, 4244, 4258, 4449, 4736 (Heeschen and Wade 1964, Epstein 1964) and optical rotation curves and mass estimates are available for NGC 4258, 4736, etc. (see chapter 3).

C4. <u>NGC 5128 Group</u> (μ_0 = 28.0, Δ = 4.0, V_0 = 319). Several large southern galaxies having low velocities (range 271 to 410) may form a loose group or chain centered on NGC 5128, and including NGC 4945, 5102, 5236, 5253 and possibly 5068 (de Vaucouleurs 1956a). Two (NGC 5102 and perhaps 5128 = Cen A) are lenticulars, three are late-type spirals Sc-Scd and one (N5253) a peculiar, late-type irregular. The overall length of the chain is 30° = 2.1 Mpc or 20° = 1.4 Mpc (excluding N5068 which has the highest velocity). The velocity range is, however, only 140 km/sec (271 to 410). Even if this chain does not form a physical (bound) group it is useful to obtain some estimates of the distance of NGC 5128. Because of the large range of galactic latitudes covered the apparent modulus varies from 28.2 (A = 0.3) for N5068 to 28.8 (A = 0.8) for NGC 4945. In addition to the extensive literature on NGC 5128 (see B.G.C. for references) some optical and radio emission data are available for NGC 4945 and 5236 (de Vaucouleurs 1964, Epstein 1964)

G5. <u>M101 Group</u> (μ_0 = 28.3, Δ = 4.6, V_0 = 508). This is a traditional group but its membership is somewhat uncertain. It is included by van den Bergh (1960d) in his extended M94 group but Holmberg (1950) and Sersic (1960) make it a separate group. An analysis of luminosities, diameters, HII regions and velocities, as well as the distribution on the sphere support the latter view. The major members, then, are M101 (N5457) and its satellites NGC 5204, 5474, 5585, and the wide pair formed by M51 (N5194 and companion N5195) and M63 (N5055); a probable member is N5949, and possibly some outlying systems including N4605, N5907, N6503, A1353 (Ho IV), and A1339 (Ho V). Many dwarfs are concentrated in this region including DDO 175, 185, 186, 191, 193, 194, around M101, and DDO 167, 168, 169, 172, 176, 177, 178, 181, 182, 183 around M51-M63. Except for NGC 5195 (type I0), all bright members of the group are spirals of type later than Sb and dwarf magellanic irregulars. The velocity range is 240 km/sec (395 to 634). The overall dimensions of the group are 23° x 16° = 1.8 x 1.3 Mpc and again there is no central condensation. In fact the group consists mainly of two sub-groups centered at M101 and M51, each about 10° x 7° = 0.8 x 0.6 Mpc an are separated by some 10° = 0.8 Mpc. The separation between the M31-M33 and Galaxy-LMC subgroups in the Local Group is about 0.? Mpc. Detailed photometric, spectroscopic and radio data are available for M51, M63, M101 (Holmberg 1950, Epstein 1964).

G6. <u>NGC 2841 Group</u> (μ_0 = 28.9, Δ = 6.0, V_0 = 589). Several large spirals near the border of UMa and Lynx have low velocities (range 422 to 751) and may form a loose group including N2841 and 2681 as the brightest members, the loose triplet of late-type spirals N2500, 2541, 2552 and the close pair formed by N2537, a peculiar

magellanic irregular, and IC 2233, an edge-on Sd, (the L classification in B.G.C. is an error). Several dwarf systems in the area including DDO 40, 41, 43, 46, 48, 49, 52, 55, 59 are possible members.

The overall dimensions 15° x 7° = 1.6 x 0.8 Mpc are normal. If the adopted modulus is correct, only one member (N2841) is brighter than -18, but N2681 is at M_G = -17.9. Little detailed information is available for these galaxies and there are no positive radio data.

G7. <u>NGC 1023 Group</u> (μ_o = 29.0, Δ = 6.3, V_o = 566). Several large spirals of type Sc and later including NGC 925, 1003, 1058, and IC 239 are clustered around the bright lenticular system N1023 in low galactic latitudes at the border of Perseus and Andromeda. The edge-on Sb system N891 and the close pair of late-type spirals N672, I1727 (V_o = 496 and 518) are probable or possible outlying members; N891, however, has the lowest velocity (+243) and N672 the largest separation (20°). N1156 (V_o = 497) a magellanic irregular some 20° away is another possible outlying member. The velocity range is 500 km/sec (243 to 741) or 250 (496 to 741), if N891 is excluded. The group is at the edge of the galactic absorption belt (which may conceal some members in lower latitudes) and the apparent modulus varies from 29.3 for N672 (A = 0.33) to 29.6 for N1003 (A = 0.64). Several dwarf irregulars are probable (DDO 24, 25 shown in "The Hubble Atlas of Galaxies", plate 39) or possible (DDO 11, 17, 19, 22, 26) members. The overall dimensions of the group 20° x 10° = 2.2 x 1.1 kpc (including N672) are rather large, but the diameter of the core around N1023 is only 8° = 0.9 Mpc.

There is little detailed optical information and no positive radio data for these galaxies (except possibly continuum emission

for N891) although two of the brightest supernovae appeared in N1003 and N1058.

G8. <u>NGC 2997 Group</u> (μ_o = 29.4, Δ = 7.6, V_o = 534). A loose group consisting of one lenticular N2784 and several large late type spirals including N2763, 2835, 2848, 2997 may be isolated in low galactic latitudes at the border of Hydra and Antlia in the foreground of the distant Hydra Cloud (μ_o = 31.5, V_o = 2074). Red shifts are known for only two objects (N2784, 2835) but the large diameters and luminosity classes of the others confirm the existence of a nearby group. The overall dimensions are 14° x 8° = 1.9 x 1.1 Mpc. Several dwarf systems including DDO 56, 57, 60, 61, 62 are in this area. The large magellanic irregular N3109 (V_o = 130) which lies about 5° nf N2997 is probably an isolated foreground object. There is very little optical or radio information on members of this group which is one of the only two nearby groups at supergalactic latitudes greater than 50°.

G9. <u>M66 Group</u> (μ_o = 29.4, Δ = 7.6, V_o = 592). This is the well-known compact triplet of spirals including M65 (N3623), M66 (N3627), and N3628 together with several outlying systems including probably (N3593, 3596, 3666) and possibly (N3485, 3489, 3506, 3547). The velocity range is 300 km/sec (429 to 730) and the overall dimensions 7° x 4° = 1.0 x 0.6 Mpc. Only a few dwarfs including D89, 91, and 108 are in this area, but N3628 has an extremely faint companion or appendage discovered by Zwicky.

The M66 group partly overlaps in both projection and velocity range with the richer and larger M96 group (G11) with which it is often combined to form an enlarged Leo group (e g. as in HMS 1956)

which will be denoted here as the Leo I cloud. Apart from optical rotation curves for M65 and M66 (cf. Chapter 3), little detailed information is available for the others outside that referenced in B.G.C.

G10. Canes Venatici II Cloud (μ_0 = 29.5, Δ = 8.0, V_0 = 747). This is part of the complex region described as the CVn (M94) cluster by van den Bergh (1960d) and as the UMa II group by Sersic (1960). A detailed analysis of magnitudes, diameters, HII regions, luminosity classes, and velocities over the whole region indicates that a dozen bright objects, (N3769, 3769A, 3949, 4051, 4088, 4111, 4143, 4242, 4485, 4490, 4625, 4618) mainly late-type spirals and irregulars (N4111, 4143 are lenticulars) form an elliptical core area measuring 15° x 8° = 2.1 x 1.0 Mpc. The overall dimensions of the cloud are increased to 22° x 12° = 3.0 x 1.6 Mpc if several probable or possible outlying members such as 3675, 4627, 4631, 4656-57, 4800, and the dwarf systems N4025, 4288 are included. The assignment of outlying objects to this cloud rather than to other overlapping or adjacent clouds or groups (CVn I, Coma I, M101) is to some extent a matter of interpretation. This is especially true of the many dwarf galaxies noted by van den Bergh (1959) in this general area (see Fig. 6); it is not possible without further detailed study to determine to which cloud they belong. Several of the brighter objects in the CVn II cloud have been the subject of fairly detailed optical and radio investigations (for references see B.G.C. and Chapter 3).

G11. M96 Group (μ_0 = 29.6, Δ = 8.3, V_0 = 741). This is the major condensation in the Leo I Cloud; it is centered on a dense core (3° x 1°5 = 0.4 x 0.2 Mpc) including N3351 (M95), 3368 (M96),

3377, 3377A, 3379, 3384, and 3412. Other probable and possible members listed in Table 3 cover an area 11° x 7° = 1.6 x 1.0 Mpc. Several dwarfs including DDO 79, 88, 89, 90 are other possible members. The morphological types show greater variety than nearer groups ranging from giant ellipticals (N3377, 3379) and lenticular (N3384) to late-type spirals and magellanic irregulars. As the nearest of the well-mixed groups the M96 group is one of the best fields for the calibration of distance indicators applicable to E and L systems (N3377 and 3379 are rich in globular clusters). The velocity range is 310 km/sec (593 to 904), rather small for a dense group.

Extensive photometric and spectroscopic studies have been made of several of the bright members, especially N3379, for which there is also a mass estimate from velocity dispersion (see References in B.G.C.). There are as yet no positive radio data, except marginal continuum emission from M95 and M96.

G12. <u>N3184 Group</u> (μ_0 = 29.9, Δ = 9.6, V_0 = 629). A few, late-type spirals with fairly large diameters and consistent velocities (range: 418 to 832 km/sec) stand out in Leo Minor in the foreground of more distant clouds. The four listed in Table 3 cover an area 10° x 5° = 1.7 x 0.8 Mpc. Two more (N3344 and 3510) 10° south of the group have velocities in the same range and might be included as possible members. There is a remarkable paucity of DDO dwarfs in this area and the reality of the group is questionable.

There is also very little detailed optical or radio information on the galaxies in this group

G13. <u>Coma I Cloud</u> (μ_0 = 29.9, Δ = 9.6, V_0 = 944). This is an elliptical area 11° x 5° = 1.8 x 0.8 Mpc enclosing two main condensations, the denser N4274 group and a loose grouping around NGC 4565. The N4274 group (van den Bergh 1960a, Sersic 1960) includes N4245, 4251, 4274, 4278, 4283, 4314, 4414, 4448 and possibly N 4062, 4146, 4203, 4359, I3330 and other insufficiently documented objects; the group has a 3° = 0.5 Mpc core surrounded by scattered objects over a 6° = 1.0 Mpc region. Morphological types are well mixed, including a pair of giant ellipticals (N4278, 4283). The grouping around N4565 includes also N4494, 4559, 4725, and A1244 (the low velocity anonymous spiral in the outskirts of the great Coma I cluster) and probably some other less well documented objects. The dimensions of this grouping are 11° x 5° = 1.8 x 0.8 Mpc. ~~Morphological types are well-mixed~~. Velocities in the N4274 group tend to be lower (range: 622 to 1078, mean: 829) than in the N4565 area (range: 876 to 1305, mean: 1134), but there is considerable overlap. A number of DDO dwarfs listed in Table 3 are other possible members of the Coma I cloud.

Except for some photometry of N4494 and 4565, there is surprisingly little detailed optical or positive radio information on members of this cloud in spite of the favorable location near the North galactic pole (see References in B.G.C.).

G14. <u>N6300 Group</u> (μ_0 = 30.0, Δ = 10.0, V_0 = +1270). Three large obscured spirals at low galactic latitudes in Ara, N6300 and the pair N6215-6221 may be the brighter members of a loose group partly hidden by the absorption belt; the pair of late-type spirals I4710, I4713 and perhaps I4662A and I4714 are other possible members

The large, low velocity magellanic irregular I4662 (V_0 = +237) is clearly in the foreground. The length of the chain is 10° = 1.7 Mpc. Because of the range of galactic latitudes the apparent modulus varies from μ = 31.1 for N6215-6221 (A = 1.1 mag.) to 30.8 for N6300 (A = 0.8) and 30.6 for I4710-13 (A = 0.5).

The large absorption correction and poorness of the group make the distance modulus quite uncertain.

17.6. Nearby Groups Beyond 10 Megaparsecs.

Table 2 lists 40 other nearby groups whose distance moduli are between 30.2 and 31.2. The apparent distribution is shown in Fig. 4. The survey is believed to be substantially complete to μ_0 = 31.0 (Δ = 16 Mpc) (see section 17.7.a.).

Table 4 lists the 5 brightest members. Some further remarks follow:

G15. Cetus I cloud: includes N1052 and N1068 groups.

G16, 21, 22. N1566, N1433, N1672 groups: parts of Dorado Cloud complex. The mean velocity of the N1433 group depending on two velocities only is uncertain. N1672: no velocity is available as yet for this southern group which is partly covered by the Large Magellanic Cloud.

G17, 24, 28, 32, 34. UMa I (Z, Y, X, S, N) groups and clouds: parts of UMa I cloud complex. UMa I (N) and UMa I (S) are merely the northern and southern halves of the same cloud at μ_0 = 30.7 - 30.8 and north of the supergalactic plane, while UMa I (X) and UMa I (Y) are apparently distinct sub-clouds of

a nearer cloud at μ_0 = 30.5 - 30.6 and south of the same plane. UMa I (Z), the southernmost grouping in the great UMa cloud complex, is actually closer to the CVn II cloud in both direction and distance (μ_0 = 30.3).

G18, 19, 25. Virgo S, Virgo E, and Virgo S': parts of Virgo I cluster. For detailed analyses of the Virgo cluster and discussions of possible foreground and background objects see (Reaves 1956, de Vaucouleurs 1961c, Holmberg 1961).

G20, 26, 35. Virgo Y, Virgo X, Virgo V: parts of Virgo II cloud complex.

G46. Virgo W group: includes the W', Wa, Wb sub-groups (see de Vaucouleurs 1961c) in the background of the Virgo I cluster.

G27. Grus cloud: (de Vaucouleurs 1956a, Shobbrook 1965). Possible foreground object: I5332 (in Sculptor group?).

G29. Virgo III cloud: includes N5566 and N5713 groups.

G31. Eridanus cloud: includes N1209 and N1332 groups.

G33. Cetus II cloud: includes N584 and N681 groups.

G36. N2207 group: this little-known southern group in low galactic latitudes has the highest supergalactic latitude of all the nearby groups.

G39. N134 group: this group is close to the south galactic pole and in the vacant center of the much nearer Sculptor group (G1).

G42, 43, 47, 48, 54. N2964, N3396, N3190, N3245: parts of Leo II cloud complex.

G45. Pavo-Indus cloud: includes N7079 and N7213 groups. Foreground: N7090 (V_0 = +730), I5152 (V_0 = +51), I5201. Background: N6970 (V_0 = +5440).

G50. N5846 group: see de Vaucouleurs, 1960a.

G51. N6643 group: foreground 6503 (V_o = +279), background N6621 (V_o = +6490).

G53. Fornax I cluster: N1316 (V_o = +1715), N1365 (V_o = +1571) possibly in foreground?, (see de Vaucouleurs 1956a, Hodge 1959, 1960).

17.7. Statistical Properties of Nearby Groups.

a. Completeness of Survey: The frequency distribution of distance moduli of the 54 groups in Table 2 plus the Local Group is given in Table 5.

A plot of the cumulative frequencies $N = \sum n$ (Fig. 5) is consistent with the relation $N \propto \Delta^3$, i.e. $\log N = a + 0.6\ \mu_0$ expected for a statistically uniform space density of cluster centers in the range $30 < \mu_0 < 31$. There is an apparent excess of nearby groups for $\mu_0 < 30$ due in part to a genuine higher density near the Local Group and in part to the fact that a finer division of groups is possible in our immediate neighborhood; at larger distances an increasing proportion of groups have been included in larger clouds. To compensate for this effect let us visualize (Fig. 8 and 9) the region of the Local Group observed from a great distance, say, from the Virgo Cluster; then, the M81, Sculptor, and Local Groups might appear merely as condensations in the same cloud (our Local Cloud) and the N5128 chain might be unnoticed. The circles and dashed line in Fig. 5 correspond to the corrected frequency function allowing for this effect. The presence of a Local Cloud is still in evidence but

the approximation to the Δ^3 law is quite good for $\mu_0 > 29$ and apparently right up to the limit of the survey at $\mu_0 \approx 31$. This is because in preparing this chapter all identifiable groups with $\mu_0 < 32$ (and many beyond) were considered and only those with $\mu_0 \leq 31.0$ (31.2 to allow for accidental errors) are discussed here. Hence the survey should be substantially complete out to $\mu_0 = 31.0$ (Δ = 16 Mpc) except, of course, for the obscured galactic belt (about one-fifth of the sky area).

b. Space Density of "Cluster" Centers: Allowing for galactic obscuration, some 50 to 60 cluster (or group or cloud) centers should lie within Δ = 16.0 Mpc, or in a spherical volume of $17 \cdot 10^3$ Mpc^3. The average volume of space per cluster or "cluster cell", then, is 300 Mpc^3 and the average distance between adjacent "cluster centers" is on the order of 7 Mpc.

For comparison the average diameter of the nearby groups, clouds and clusters is about 2 Mpc; most condensations are well separated by regions of lower density.

c. Frequency Function of Diameters: Table 6 gives the distribution of major diameters of groups and clouds or clusters

Median and mean diameters are: Groups 1.5/1.5 Mpc (range 0.3-2.5), clouds and clusters: 2.3/2.[illegible] Mpc (range 1.8-3.6). There is a suggestion of bimodal distributions: small groups (0.3-1.2 Mpc), large groups (1.4-2.5 Mpc); small clouds or clusters (1.8-2.5 Mpc), large clouds (2.8-3.6 Mpc).

d. Luminosity Function. The mode of formation of the Reference Catalogue prevents the derivation of a meaningful luminosity

function for groups other than the Local Group (section 17.4) except for the very brightest galaxies. Table 7 gives the numbers N_{18} and N_{17} of systems with $M_G < -18$ and $M_G < -17$ in the B(0) system (remember that M_T is about 0.5 mag. brighter on the average) for 38 groups (including the Local Group) and 17 clouds or clusters. The counts appear to be complete to -17 for $\mu_0 < 30.0$ only, and to -18 for $\mu_0 < 31.0$. The average population is $\overline{N}_{18} = 4.3$ for groups and $\overline{N}_{18} \approx 15$ for clouds and clusters. On the average a cloud or cluster (as defined here) comprises 3 or 4 groups. This is consistent with the ratio of average diameters $(2.5/1.5)^3$ and the statistical relation between volume and average density in nearby space (de Vaucouleurs 1960a, 1961d).

e. Statistical Masses: The loose structure of most nearby groups does not inspire confidence in their stability nor in the validity of total masses derived from velocity dispersion through the virial theorem (Local Group: Humason and Wahlquist 1955, Kahn and Woltjer 1959, Godfredsen 1961; Sculptor Group: de Vaucouleurs 1959; M81 Group: Holmberg 1950, Ambartsumian 1958, Limber 1961; CVn Cluster: van den Bergh 1960d; Virgo Cluster: Oort 1958, van den Bergh 1960d, Holmberg 1961, de Vaucouleurs 1961c, N5846 Group: de Vaucouleurs 1960a; see also Report on Santa Barbara Symposium by Neyman, Page, and Scott 1961).

Although the evidence is perhaps not yet completely conclusive the overall impression gained from the extensive discussion of this topic at the Santa Barbara Conference is that while large, centrally condensed clusters of the Coma type are probably sufficiently relaxed and stable over periods of time long enough to justify an

application of the virial theorem, the same cannot be said of the majority of nearby groups and clouds with the possible exceptions of the E components of the Virgo I and Fornax I clusters. Hence masses derived from velocity dispersion are probably meaningless.

There is, therefore, little point in applying the virial theorem to each of the 55 nearby groups and clouds. It should be sufficient to list the average masses and densities that would result from a conventional application of the standard method to the mean of all nearby groups and clouds.

The calculations use the crude but sufficient approximation $\mathfrak{M}_T \approx 5R\sigma_v^2/G$, where $R \approx \bar{D}/4$, if $\bar{D}$ = mean major diameter of groups, and $\sigma_v^2 \approx 2(\overline{A.D.})$, if $(\overline{A.D.})$ = mean of average deviations from V_o in Table 2. The results shown in Table 8 display the familiar discrepancy between average galaxy masses from rotational studies ($\sim 10^{10} \odot$) and from the virial theorem ($\sim 10^{11} - 10^{12} \odot$). It is more pronounced for the three clusters than for groups or clouds. Rejection of possible foreground or background objects in Virgo reduces the discrepancy only slightly (de Vaucouleurs 1961c, Holmberg 1961).

f. Population Types: There is a remarkable segregation of galaxy types among nearby groups and clouds; this phenomenon which was first noted in the Grus Cloud (de Vaucouleurs 1956a), the UMa I Cloud (Morgan 1958) and the "M94 Group" (van den Bergh 1960d) is probably related to differences in age and/or physical conditions (gas density, temperature, composition) at the time of formation of the groups.

A quantitative index of population type can be obtained by means of a numerical scale attached to the classification stage as

follows:

$\mathcal{T}$	E	E^+	L^-	L	L^+	I0	S0/a	Sa	Sab	Sb	....	Sdm	Sm	Im
t	-6	-5	-4	-3	-2	-1	0	1	2	3		8	9	10

In principle accurate color indices could be used, but in addition to the fact that color indices are not yet available for all galaxies in nearby groups, the color scale is too compressed in the early types ($t < 0$) and it is sensitive to absorption and emission. Table 7 gives the mean type index t, range and average deviation S_t (a "purity" index) of the 4 to 6 brightest galaxies in nearby groups.

Nearly all the nearer groups are "S" type, i.e. have a large majority of spirals and magellanic irregulars with an occasional lenticular or I0 system and practically no giant elliptical. Among all the nearby groups only the "E" core of the Virgo cluster and the Fornax I cluster have a dominant population of ellipticals.

17.8. Nearby Dwarf Galaxies.

a. Definition: A dwarf galaxy may be defined in terms of absolute magnitude and/or linear size. There is, however, a continuous transition between giant, average and dwarf galaxies. The separation must rest on some arbitrary demarkation lines. As far as we know lenticulars and spirals in the Sa-Sc range are all brighter than $M_T = -16$; dwarf systems fainter than -16 occur only among ellipticals and late-type spirals Sd-Sm or magellanic irregulars Im, but, of course, not all E or Im systems are dwarfs. For instance, by this definition the Large Magellanic Cloud ($M_T = -18.1$)

is certainly not a dwarf and the Small Cloud (M_T = -16.0) is a borderline case, but M32 (M_T = -15.6) and NGC 205 (M_T = -15.8) qualify as dwarfs. Similar systems in the Virgo cluster are N4486B, the bright compact dE0 companion of M87, and IC 3475, the prototype of the low-luminosity diffuse ellipticals described by Reaves (1956), which are both at M_T = -16.0. The low-luminosity dwarf ellipticals of the Local Group exemplified by the Sculptor and Fornax systems are much fainter, respectively at M_T = -11.2 and -12.9, and the extreme dwarf globular-like systems discovered by Wilson (1955) and Zwicky (1957) are fainter still, for example Leo II is at M_T = -9.1.

The lower end of the scale is indefinite and for all we know (or rather do not know) "pigmy" systems of even smaller populations down to isolated star-cluster size might exist and remain undetected throughout intergalactic space as Zwicky has often argued (1957).

b. Dwarfs in the Local Group: The provisional and certainly incomplete luminosity function of the Local Group (section 17.4) has only six average or giant members (M_T < -16) and a score of dwarfs fainter than -16 of which 6 (or 7 including SMC) are magellanic irregulars in the range -16 to -12 and 15 are spheroidal systems in the range -16 to -9 or fainter. This is a minimum because extreme dwarf ellipticals of the Sculptor-Fornax type are observable only if $\mu \leq 22$ (μ_0 < 21.5 or $\Delta \leq 0.2$ Mpc) since their discovery on the Palomar Sky Survey plates requires $m_* \leq 20.5$ (if $M_* \approx -1.5$); the fact that a dozen are known within this range suggests that their space density is high (50 to 100 per Mpc^3), unless they are satellites of our Galaxy, perhaps related to globular clusters (Wilson 1955) rather than independent galaxies. Star counts in several of the

largest dE systems (Hodge 1960-64) and indicating tidally limited radii favor the second alternative. There is only a marginal possibility of detecting such systems at the distance of the Andromeda group even with the largest reflectors ($\mu \leq 25$, $m_* \leq 23.5$). A *fortiori* such systems are beyond the reach of the largest telescopes even in the nearest groups ($\mu > 27$, $m_* > 25.5$). For all practical purposes we may be missing the most common type of galaxy in the Universe, much as we fail to detect all except a few of the nearest dwarf stars of $M > +10$.

To a lesser extent the same remark applies to the dwarf magellanic irregulars of the IC 10 - IC 1613 type of which at least six are known in the Local Group. The presence of blue supergiants and HII regions, however, makes them more easily detectable and well beyond the Local Group ($\mu < 30$ if $m_* < 21$ to 22 and $M_* = -8$ to -9).

Small ellitpcals of the M32 - NGC 205 type are also observable beyond the Local Group, but their small diameters make them difficult to distinguish from star images at the distance of the Virgo cluster. For instance M32 with a standard linear diameter D(0) = 0.6 kpc would have an apparent diameter of 0!2 only at the adopted distance Δ = 12.6 Mpc of the Virgo cluster and would, therefore, look very much like NGC 4486B which is undistinguishable from star images on survey plates.

c. Survey of Nearby Dwarfs: The only systematic search for nearby dwarf galaxies was made by van den Bergh (1959) on the 48-inch Sky Survey prints. Criteria for identification depend mainly on low surface brightness and density gradient in an image of diameter 1' or larger. Compact dE systems are therefore excluded.

Most objects must be dIm and low density dE systems except for a few resolved Local Group "pigmies" and some occasional misidentifications. The apparent distribution in supergalactic coordinates of the DDO dwarfs is shown in Fig. 6; the large gap is the unobserved southern sky ($\delta < -23°$). The symbols correspond to van den Bergh's classification:

DIr: dwarf magellanic irregulars of the N6822, IC 1613, WLM type.

DSp: dwarf spirals which from van den Bergh's description are clearly late-type barred spirals of the SBd-SBm types or magellanic irregulars of the SMC-LMC type.

DEl: dwarf ellipticals of the N205 type of which only a few of the nearer and larger ones can be identified on the Sky Survey prints.

DSph: dwarf spheroidal galaxies of the IC 3475 type in the Virgo cluster. (van den Bergh notes that resolved systems of this type in the Local Group such as Draco are difficult to distinguish from clusters of distant galaxies on the Survey prints).

Local Group members and objects larger than 1.0 are identified by open circles in Fig. 6.

The nearby dwarfs are clearly concentrated to the supergalactic equator, especially in the northern (galactic) hemisphere and several condensations corresponding to the nearby groups can be recognized (compare with Fig. 3 and 4), in particular the M81 and M101 groups, the Vir I cluster, and CVn I, CVn II, Vir II clouds. Probable or possible associations of DDO dwarfs with some individual groups are noted in Table 3. In most cases, however, definite proof of

association will require more detailed studies.

d. Completeness of Survey. The frequency function of apparent diameters for the DDO dwarfs is as follows:

ϕ	16'	8'	4'	3'	2'	1'5	1'
n	1	6	8	12	29	46	120
$N=\sum n$	1	7	15	27	56	102	222

A log ϕ - log N plot approximates closely the $N \propto \phi^{-3}$ distribution expected for a statistically uniform space density in the range $11' < \phi < 20'$, but falls off rapidly for $\phi < 10'$. Either incompleteness begins at $\phi = 10'$ or there is a local excess of dwarfs associated with the Local Group. The 7 largest DDO dwarfs ($\phi \geq 8'.0$) are listed below: six (D8, 74, 199, 208, 209, 221) are in the Local Group and one (D81) is in the M81 group.

DDO DWARFS > 8'

DDO	ϕ	Δ (Mpc)	ϕ kpc
8 = I1613	15'.0	0.66	3.1
74 = Leo I	8'.5	0.23	0.6
81 = I2574	11'.5	2.5	8.5
199 = UMi	20'.0	0.08	0.5
208 = Draco	8'.0	0.06	0.14
209 = N6822	12'.5	0.50	1.8
221 = WLM	11'.0	0.87	2.8

If the smallest DDO dwarfs ($\phi = 1'.0$) have the same mean linear diameter $\bar{\Phi} = 2.5$ kpc as the 7 above the limiting range of the survey

is $\Delta \approx 8.5$ Mpc on the average; half the total ($\phi \approx 1'5$) is within an average range of 5.5 Mpc. However the range of linear diameters is large (8.5 to 0.14 kpc or a 60:1 ratio in the first seven) and the range of the survey in depth is necessarily indefinite.

For a survey of dwarf galaxies in the Virgo cluster, see (Reaves, 1956).

17.9. Isolated Nearby Galaxies.

Thirty years ago galaxies were generally regarded as primarily distributed in a so-called "general field", i.e. more or less isolated in space, with only a small minority in occasional groups or clusters. More recently there has been some speculation that perhaps the opposite is true and that all galaxies are clustered (even if some stochastic models include "clusters" having n = 1 member!). Holmberg (1940) has counted apparent companions of a selected sample of G. C. objects ($10 < m < 13$) in the Reinmuth Survey; after statistical correction for optical companions and incompleteness he derived the following relative frequencies:

Multiplicity m	1	2	3	4	5	6	7
Frequency (%) f	47	24	15	7	4	(2)	(1)
$f = 2^{-m}$	50	25	12.5	6.25	3.12	1.56	0.78

Thus 47% of all galaxies of $10 < m < 13$ appear to be single, 24% are members of pairs, 15% of triplets, etc. It is perhaps more than a passing curiosity that the observed frequencies are well approximated by $f(m) = 2^{-m}$ which suggests that for all $m \geq 8$, $\sum f = 1.3\%$ Statistics based on apparent magnitudes refer to an indefinite volume of

space and frequencies depend very much on the operational definition of a group. Holmberg's counts refer mainly to dense groups and multiplets and include only a small fraction of the loose groups considered in this chapter.

Ideally counts should refer to a specified volume of space, but this is not practical and even then the problem of dwarf galaxies (how far down the luminosity function should one place the cut-off) will complicate matters.

The present data on nearby groups may nevertheless help to answer the simpler question: are there isolated galaxies? Figure 7 shows the distribution in supergalactic coordinates of all galaxies in the Reference Catalogue which are either brighter than B(0) = 10.0 (or corrected Shapley-Ames magnitude m_c), or larger than D(0) = 10$^{\prime}$.0 or have corrected radial velocities V_o < +200 km/sec (adding IC 10, IC 342 with allowance for absorption). Out of the 60 galaxies in this objectively selected sample only 8 have not been associated with one of the 55 nearby groups, viz. NGC 404, 1313, 2303, 3109, 3521, 6744, 6946, and IC 5152. In addition there is a possibility that a few galaxies such as NGC 1316, 4594, 4826, are not really members of the groups (For I, Vir Y, CVn I) to which they have been tentatively assigned. Furthermore, the reality of the NGC 5128 chain as a physical unit may be questionable; but, then, it is difficult to know where to stop in this "dismemberment" of loose groups and the logical outcome of an over conservative attitude would be to exclude from consideration all but a few rich clusters and dense groups (the Local Group itself would not hold too well under this critical approach). By the definitions set up in section 1 we must

conclude that not more than 8 to 14 of the 60, i.e. 13 to 23%, of the "outstanding" nearby galaxies are isolated in space. This is only one quarter to one half of Holmberg's estimate.

On the other hand several of the 8 supposedly isolated galaxies might upon further investigation turn out to be members of some of the nearer groups; in particular NGC 404, 3109, and IC 5152 should be examined for possible membership in the Local Group. Other (more remote) possibilities are N1569, IC 342 and perhaps some heavily obscured systems as yet unrecognized. For example, IC 10 although long suspected was only recently established as a Local Group member (Roberts 1962, de Vaucouleurs and Ables 1965). If this were the case the frequency of isolated galaxies might be reduced to 10 per cent or less, again depending somewhat on how strictly or loosely a group is defined. Nevertheless it seems difficult to reduce the frequency to zero; to the writer's knowledge NGC 1313, and 6744 in the southern sky and probably NGC 2903, and 6946 in the northern sky are truly isolated galaxies not associated with any nearby group (of course, both are in the larger Local Supercluster discussed in section 10).

17.10. Apparent and Space Distribution of Nearby Groups; Local Supercluster.

The apparent distribution of nearby groups (Fig. 3, 4) strongly reflects the concentration of bright galaxies toward the plane of the Local Supercluster (Holmberg 1937; de Vaucouleurs 1953, 1956b, 1958, 1960b; Carpenter 1961, Abell 1961).

Table 9 gives counts of various systems ("outstanding" galaxies,

DDO dwarfs and nearby groups) as a function of Supergalactic latitude separately for the center sector (northern galactic hemisphere) and anti-center sector (southern galactic hemisphere). Comparison of the observed relative frequencies within 10°, 20°, or 30° from the supergalactic equator with the values computed for a random (uniform) distribution (with allowance for galactic obscuration from the Hubble counts of faint galaxies) brings out the strong concentration of all systems to the supergalactic plane. The only possible exception is the Local Group which is not surprising considering its small volume and our location in it. For all other systems some 75 to 100 per cent of the total population is within 30° of the supergalactic equator (means: 88% in N.G.H., 80% in S.G.H.), as compared with 59% for a uniform distribution. The average ratio O/C = (observed)/(computed) varies with supergalactic latitude as follows:

	(0, ±10°)	(0, ±20°)	(0, ±30°)
Galaxies: O/C	2.3	1.75	1.45
Groups: O/C	2.15	1.45	1.35

The flattened local supersystem is also clearly in evidence when the space distribution of the 55 nearby groups and clouds is mapped as in Fig. 8 and 9. The supergalactic rectangular coordinate system is defined as follows: OX = line of nodes of supergalactic and galactic planes, X > 0 in direction L = 0° defined by $\ell^I = 105°$, $b^I = 0°$ (de Vaucouleurs 1958, 1960b), OY = direction of L = 90° (in Coma), OZ = direction of supergalactic north pole at $\ell^I = 15°$, $b^I = +5°$. Fig. 8 is a projection in the (Y, Z) plane and since the center of the supercluster is apparently in the direction of the Virgo cluster

($L = 104°$) this projection approximates a meridional cross-section. Note the accumulation of groups within 5 Mpc from the supergalactic plane for $Y > -5$ Mpc. The dashed line marks the radius ($\Delta = 16$ Mpc) of the survey. The third coordinate X is shown in each group. The shaded 20° fan along the Z axis marks the approximate limits of the galactic zone of avoidance. Note the wide gap (not due to obscuration) between the Sculptor group and the more distant groups in the southern hemisphere ($Y < 0$).

Fig. 9 is a projection in the supergalactic (X, Y) plane of the groups and clouds for which $|Z| < 3$ Mpc (full circles) and $3 < |Z| < 5$ Mpc (dashed circles). The value of Z is shown for each group. This is a first approximation map of that part of the "Local Supergalaxy" which falls within the 16 Mpc radius of the survey. Galaxy counts (Reiz 1941, de Vaucouleurs 1956b, 1960b, Carpenter 1961) indicate that the Local condensation extends ~~for~~ to about twice this distance beyond the Virgo cluster or to $Y \simeq +30$. The Local supercluster, then, may encompass all groups and clouds within a radius of 15 to 20 Mpc from a center in the general vicinity of the Virgo cluster (there is no necessity for the center of mass to be within any particular cluster) and within 5 to 10 Mpc from the supergalactic plane. This includes the majority of the northern nearby groups and clouds but probably excludes most of the southern clouds beyond 7 or 8 Mpc.

Note the strong indications of sub-clustering within the supersystem; as already noted there is evidence for a "Local Cloud" (or cloud complex) including the Local Group, Sculptor, M81, M101, N2841, N1023, N5128 groups and CVn I; another cloud complex could

include CVn II, Coma I and UMa I (Z); other examples are UMa I (N+S, X, Y), Virgo II (X, Y, V), and Leo II.

The Local Cloud includes all the nearer groups within $\Delta \approx 7$ Mpc and with very few exceptions comprises only spirals and magellanic irregulars among its 40 or 50 brighter members; the average type index is $\bar{t} = +5.1$ ($\overline{s_t} = 2.9$). For comparison the average type index is $\bar{t} = +3$ for all groups in the range $7 < \Delta < 15$ Mpc and $\bar{t} = 0$ for $\Delta > 15$ Mpc.

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TABLE 1a. Local Group

Object		ℓ^{II} / b^{II}	SGL / SGB	Type	$\mathcal{L}$	B(0) / V_o	log D / log R	logD(0) (')	D(0) (kpc)
Galaxy		-	-	Sc?		-	-	-	(12)
		-	-		-	-	-		
N 147		119.8	344.0	E5p		11.48	0.78	0.70	1.0
	D 3	-14.3	15.3		-	-	0.22		
N 185		120.8	344.0	E^+3p		10.92	0.73	0.70	1.0
		-14.5	14.3		-	-10	0.07		
N 205		120.7	337.2	E^+5p		9.71	1.00	0.88	1.5
		-21.1	13.1		-	-6	0.29		
N 221		121.2	336.5	E2		9.39	0.56	0.51	0.6
		-22.0	12.5		-	+17	0.12		
N 224	M 31	121.2	336.9	SA(s)b		4.61	2.20	2.00	20.0
		-21.6	12.6		2	-68	0.49		
N 598	M 33	133.6	329.2	SA(s)cd		6.47	1.79	1.70	10.5
		-31.3	-0.1		4	-11	0.21		
N6822		25.4	229.8	IB(s)m		9.49	1.22	1.16	2.1
	D209	-18.4	57.1		8	+73	0.13		
I 10		119.0	355.1	SB(s)m		12.5:	0.60	0.54	1.3
		-3.3	17.9		7	-92	0.15		
I1613		129.9	299.9	Im		11.02	1.05	1.02	2.0
	D 8	-60.6	-1.8		-	-129	0.07		
SMC	A0051	302.8	224.9	IB(s)m		3.1:	2.4:	2.3:	2.9
		-44.3	-14.8		-	-13	0.30		
Scl	A0058	287.8	264.7	dE		-	-	-	-
		-83.2	-9.6		-	-	-		
For	A0237	237.3	266.0	dE		-	-	-	-
		-65.7	-30.2		-	-70	-		
LMC	A0524	280.5	216.5	SB(s)m		1.2:	2.7:	2.65:	6.5
		-32.9	-34.1		-	+16	0.07		
Leo A	A0956	196.9	70.6	Im		-	-	-	-
	D 69	52.4	-25.8		-	-	-		
Sex (B)	A0957	233.2	96 1	Im		-	-	-	-
	D 70	43.8	-39.6		-	-	-		

Table 1. Continued

Sex (C)	A1003	240.1	103.2	dE		-	-	-	-
		41.9	-40.4		-	-	-		
Leo I	A1006	226.0	89.6	E4		-	-	-	-
	D 74	49.1	-34.6		-	-	-		
Sex A	A1009	246.2	109.8	IBm		-	0.73	0.70	1.5
	D 75	39.9	-40.6		-	+118	0.09		
Leo II	A1111	220.1	87.8	dE		-	-	-	-
	D 93	67.2	-16.3		-	-	-		
UMa	A1127	202.3	83.0	dE		-	-	-	-
		71.8	-10.2		-	-	-		
UMi	A1508	105.1	48.4	dE		-	-	-	-
	D199	44.8	27.1		-	-	-		
Ser	A1513	0.9	128.[illegible]	dE		-	-	-	-
		45.9	33.[illegible]		-	-	-		
Dra	A1719	86.4	44.5	dE		-	-	-	-
	D208	34.7	44.2		-	-	-		
Cap	A2144	30.5	257.1	dE		12.37	0.68	0.68	-
		-47.7	34.0		-	-	0.00		
Peg	A2304	87.1	303.2	dE		-	-	-	-
		-42.7	29.1		-	-	-		
WLM	A2359	75.7	278.5	Im		-	0.8:	0.7:	1.3
	D221	-73.6	8.1		-	+2	0.3:		

Explanations of Columns:

Col. (1) Identification in NGC, IC, B.G.C., or DDO.

(2) New galactic coordinates ℓ^{II}, b^{II}.

(3) Supergalactic coordinates SGL, SGB (cf. B.G.C.).

(4) Revised type and DDO luminosity class coded as in B.G.C.

(5) B(0) = B mag. within standard "face-on" diameter D(0) (cf. B.G.C.)

V_o = corrected red shift.

(6) log D = log major diameter in standard system (D in min. of arc).

log R = log D/d = log axis ratio.

(7) log D(0) = log "face-on" major diameter (min. of arc).

TABLE 1b. Local Group

Object	μ	A_B	μ_o	Δ	B_T	$-M_T$	X	Y	Z
Galaxy	-	-	-	0.01	-	(18.8)	0	0	0
N 147	25.0:	0.8	24.2:	0.69	10.6	14.4	+0.64	-0.18	+0.18
N 185	25.0:	0.8	24.2:	0.69	10.3	14.7	+0.64	-0.18	+0.17
N 205	24.7	0.5	24.2	0.69	8.9	15.8	+0.62	-0.26	+0.16
N 221	24.7	0.5	24.2	0.69	9.1	15.6	+0.62	-0.27	+0.15
N 224	24.7	0.5	24.2	0.69	4.4	20.3	+0.62	-0.26	+0.15
N 598	24.6	0.3	24.3:	0.72	6.3	18.3	+0.62	-0.37	0.00
N6822	24.1	0.6	23.5	0.50	9.3	14.8	-0.18	-0.21	+0.42
I 10	29.0	3.5:	25.5:	1.26	11.7	17.3	+1.20	-0.10	+0.39
I1613	24.3	0.2	24.1	0.66	10.1	14.2	+0.33	-0.57	-0.02
SMC	18.8	0.3	18.5	0.05	2.8	16.0	-0.03	-0.03	-0.01
Scl	20.4:	0.2	20.2:	0.11	9.2	11.2	-0.01	-0.11	-0.02
For	22.0:	0.2	21.8:	0.23	9.1	12.9	-0.01	-0.20	-0.12
LMC	18.7	0.4	18.3	0.05	0.6	18.1	-0.03	-0.02	0.03
Leo A	25.4:	0.2	25.2:	1.10	13.1	12.3	+0.33	+0.93	-0.48
Sex (B)	-	0.3	-	-	12.0	-	-	-	-
Sex (C)	21.0:	0.3	20.7:	0.14	-	-	-0.02	+0.10	-0.09
Leo I	22.0:	0.2	21.8:	0.23	11.3	10.7	0.00	+0.19	-0.13
Sex A	25.3:	0.3	25.0:	1.00	11.7	13.6	-0.26	+0.71	-0.63
Leo II	22.0:	0.2	21.8:	0.23	12.9	9.1	+0.01	+0.22	-0.06
UMa	20.5:	0.2	20.3:	0.12	-	-	+0.01	+0.12	-0.02
UMi	19.6:	0.3	19.3:	0.08	-	-	+0.05	+0.05	+0.04
Ser	-	0.3	-	-	-	-	-	-	-
Dra	19.4:	0.4	19.0	0.06	-	-	+0.03	+0.03	+0.04
Cap	-	0.3	-	-	-	-	-	-	-
Peg	21.5:	0.3	21.2:	0.17	-	-	+0.08	-0.12	+0.08
WLM	24.9:	0.2	24.7:	0.87	11.2	13.7	+0.13	-0.85	+0.12

TABLE 1b. Continued

Explanations of Columns:

Col. (1) Identification.

(2) Apparent modulus μ in B system.

(3) Galactic absorption A_B in B system.

(4) Corrected (geometric) apparent modulus μ_0.

(5) Distance Δ in megaparsecs.

(6) Apparent total (asymptotic) magnitude B_T in B system.

(7) Absolute magnitude $-M_T$ in B system.

(8), (9), (10) Projection of Δ (Mpc) on OX, OY, OZ axes of supergalactic rectangular coordinate system.

TABLE 2. Elements of 54 Nearby Groups

Nr.	Group, Cluster, Cloud,	ℓ^{II} b^{II} (°)	SGL SGB (°)	μ A_B (mag.)	μ_o Δ (Mpc)	D x d (°) (Mpc)	V_o n^o A.D.	X Y Z
G 1	Scl	5	265	27.1	26.9	25 x 20	142	+ 0.1
		-80	-3	0.2	2.4	1.0 x 0.8	6	- 2.4
							134	- 0.2
G 2	M81	142	42	27.3	27.0	40 x 20	160	+ 1.8
	(N3031)	+41	+1	0.3	2.5	1.8 x 0.9	9	+ 1.7
							66	+ 0.0
G 3	CVn I	162	82	28.1	27.9	28 x 14	342	+ 0.5
		+80	+5	0.2	3.8	1.9 x 0.9	9	+ 3.8
							69	+ 0.2
G 4	N5128	310	155	28.5	28.0	30 x -	319	- 3.8
		+20	-5	0.5	4.0	2.1 x -	5	+ 1.3
							55	- 0.4
G 5	M101	102	64	28.5	28.3	23 x 16	508	+ 1.8
	(N5457)	+60	+23	0.2	4.6	1.8 x 1.3	8	+ 3.8
							85	+ 1.7
G 6	N2841	170	45	29.2	28.9	15 x 7	589	+ 3.7
		+34	-20	0.3	6.0	1.6 x 0.8	4	+ 4.4
							122	- 1.6
G 7	N1023	145	341	29.6	29.0	20 x 10	566	+ 5.9
		-20	-8	0.6	6.3	2.2 x 1.1	8	- 1.9
							127	- 1.0
G 8	N2997	250	133	30.0	29.4	14 x 8	534	- 3.0
		+19	-53	0.6	7.6	1.9 x 1.1	2	+ 3.1
							-	- 6.3
G 9	M66	241	97	29.6	29.4	7 x 4	592	- 0.9
	(N3627)	+64	-19	0.2	7.6	1.0 x 0.6	5	+ 7.1
							74	- 2.4
G10	CVn II	138	73	29.7	29.5	22 x 12	747	+ 2.4
		+75	+3	0.2	8.0	3.0 x 1.6	15	+ 7.7
							71	+ 0.3
G11	M96	231	93	29.8	29.6	11 x 7	741	- 0.7
	(N3368)	+58	-26	0.2	8.3	1.6 x 1.0	9	+ 7.4
							80	- 3.6
G12	N3184	176	67	30.1	29.9	10 x 5	629	+ 4.0
		+60	-13	0.2	9.6	1.7 x 0.8	4	+ 8.4
							122	- 2.7

TABLE 2. Continued

G13	Coma I	198	89	30.1	29.9	11 x 5	944	+ 0.1
		+86	+3	0.2	9.6	1.8 x 0.8	15	+ 9.5
							170	+ 0.5
G14	N6300	329	195	31.0	30.0	10 x 3	1270	- 9.5
		-15	+10	1.0	10.0	1.7 x 0.6	3	- 2.7
							100	+ 1.6
G15	Cet I	178	300	30.5	30.2	12 x 9	1513	+ 4.7
		-56	-27	0.3	11.0	2.2 x 1.7	7	- 8.6
							200	- 5.0
G16	N1566	265	235	30.6	30.3	5 x 5	999	- 4.9
		-43	-40	0.3	11.5	1.0 x 1.0	5	- 7.2
							156	- 7.5
G17	UMa I (Z)	165	77	30.5	30.3	10 x 4	979	+ 2.3
		+75	-1	0.2	11.5	1.8 x 0.7	2	+10.2
							-	- 0.2
G18	Vir S	284	103	30.5	30.3	12 x 12	1087	- 2.7
		+75	-3	0.2	11.5	2.3 x 2.3	21	+11.2
							780	- 0.6
G19	Vir E	284	103	30.5	30.3	12 x 12	1013	- 2.7
		+75	-3	0.2	11.5	2.5 x 2.5	38	+11.2
							413	- 0.5
G20	Vir Y	304	127	30.7	30.4	14 x 7	1307	- 7.2
		+52	-2	0.3	12.0	2.9 x 1.4	13	+ 9.6
							322	- 0.6
G21	N1433	253	248	30.7	30.5	7 x 5	665	- 3.6
		-49	-42	0.2	12.5	1.5 x 1.1	2	- 9.0
							-	- 7.9
G22	N1672	270	226	30.8	30.5	5 x ?	?	- 6.3
		-38	-39	0.3	12.5	1.0 x ?		- 7.1
							-	- 8.1
G23	N3672	273	121	30.8	30.5	8 x 6	1583	- 5.9
		+49	-22	0.3	12.5	1.8 x 1.3	2	+ 9.9
							-	- 5.2
G24	UMa I (Y)	162	66	30.7	30.5	9 x 4	998	+ 4.9
		+64	-5	0.2	12.5	2.0 x 0.8	1	+11.5
							-	- 1.0
G25	Vir S'	287	107	30.7	30.5	3 x 2	1541	- 3.6
		+70	-4	0.2	12.5	0.6 x 0.4	3	+11.9
							277	- 0.8

TABLE 2. Continued

G26	Vir X	293	113	30.7	30.5	13 x 7	1272	- 5.0
		+65	-3	0.2	12.5	2.8 x 1.5	18	+11.4
							365	- 0.5
G27	Grus	348	250	30.8	30.6	8 x 6	1561	- 4.4
		-65	+8	0.2	13.2	1.9 x 1.5	8	-12.0
							112	+ 2.6
G28	UMa I (X)	150	56	30.8	30.6	7 x 5	1090	+ 7.5
		+54	-2	0.2	13.2	1.6 x 1.1	1	+10.8
							-	- 0.5
G29	Vir III	352	122	30.9	30.6	15 x 11	1729	- 6.1
		+55	+24	0.3	13.2	3.5 x 2.5	11	+10.4
							149	+ 5.3
G30	N5866	90	62	31.0	30.7	6 x 3	920	+ 5.8
		+52	+32	0.3	13.8	1.4 x 0.7	3	+10.3
							130	+ 7.2
G31	Eri	212	282	30.9	30.7	15 x 12	1574	+ 2.5
		-55	-40	0.2	13.8	3.6 x 2.9	19	-10.8
							160	- 8.2
G32	UMa I (S)	143	70	30.9	30.7	9 x 7	1016	+ 4.8
		+69	+3	0.2	13.8	2.2 x 1.7	5	+12.9
							63	+ 0.9
G33	Cet II	160	292	31.0	30.8	9 x 8	1929	+ 5.1
		-68	-15	0.2	14.5	2.3 x 2.0	6	-13.0
							95	- 4.0
G34	UMa I (N)	141	61	31.0	30.8	8 x 5	1074	+ 7.1
		+60	+3	0.2	14.5	2.0 x 1.3	8	+12.6
							95	+ 0.5
G35	Vir V	298	121	31.0	30.8	8 x 5	879	- 7.1
		+57	-6	0.2	14.5	2.0 x 1.2	1	+12.6
							-	- 1.5
G36	N2207	230	264	31.4	30.9	6 x 5	1827	- 0.3
		-18	-78	0.5	15.	1.5 x 1.2	3	- 2.8
							419	-14.7
G37	N5676	88	70	31.1	30.9	6 x 2	2411	+ 4.7
		+60	+28	0.2	15.	1.5 x 0.5	3	+12.4
							49	+ 7.0
G38	N6876	324	214	31.3	30.9	6 x 2	?	-12.5
		-32	+3	0.4	15.	1.5 x 0.5		- 8.3
							-	+ 0.6

G39	N134	340	265	31.2	31.0	6 x 5	1786	- 1.8
		-84	-4	0.2	16.	1.6 x 1.4	2	-15.9
							-	- 1.0
G40	N488	138	302	31.2	31.0	4 x 2	2336	+ 8.9
		-58	-6	0.2	16.	1.0 x 0.5	3	-13.2
							46	- 1.4
G41	N2768	154	43	31.3	31.0	7 x 4	1681	+11.3
		+40	-8	0.3	16.	1.9 x 1.1	7	+10.8
							160	- 2.6
G42	N2964	194	66	31.2	31.0	9 x 4	1463	+ 5.5
		+50	-27	0.2	16.	2.5 x 1.1	5	+13.1
							89	- 7.4
G43	N3396	193	75	31.2	31.0	1 x 1	1599	+ 3.9
		+63	-16	0.2	16.	0.3 x 0.3	4	+14.9
							73	- 4.3
G44	N3923	287	142	31.3	31.0	6 x 3	1635	-11.7
		+33	-20	0.3	16.	1.6 x 0.8	4	+ 9.0
							172	- 5.7
G45	Pavo-Indus	344	230	31.3	31.0	13 x 8	2224	- 9.9
		-45	+14	0.3	16.	3.6 x 2.2	9	-11.7
							472	+ 3.8
G46	Vir W	283	108	31.2	31.0	3 x 2.5	2168	- 5.1
		+69	-6	0.2	16.	0.8 x 0.7	5	+14.9
							187	- 1.9
G47	N3190	213	82	31.3	31.1	4 x 3	1198	+ 2.1
		+55	-28	0.2	16.5	1.2 x 0.9	7	+14.5
							94	- 7.7
G48	N3504	204	80	31.3	31.1	5 x 2	1437	+ 2.4
		+64	-17	0.2	16.5	1.4 x 0.5	3	+15.7
							30	- 4.5
G49	N3607	232	93	31.3	31.1	4 x 2	1057	- 0.8
		+67	-17	0.2	16.5	1.1 x 0.5	7	+15.4
							229	- 4.6
G50	N5846	0	125	31.4	31.1	2.5 x 2.5	1806	- 8.1
		+48	+32	0.3	16.5	0.7 x 0.7	8	+11.4
							290	+ 8.7
G51	N6643	105	31	31.5	31.1	7 x 3.5	1938	+12.3
		+28	+31	0.4	16.5	2.0 x 1.0	5	+ 7.0
							262	+ 8.5
G52	N6861	355	223	31.4	31.1	7 x 4	2909	-11.5
		-33	+25	0.3	16.5	2.0 x 1.2	2	- 9
							-	+ 6.7

Table 2. Continued

G53	For I	237	263	31.3	31.1	7 x 7	1464	- 1.5
		-55	-42	0.2	16.5	2.0 x 2.0	12	-12.2
							260	-10.1
G54	N3245	202	71	31.4	31.2	2 x 1	1256	+ 3.9
		+58	-22	0.2	17.5	0.5 x 0.2	3	+15.8
							96	- 6.7

Explanation of columns:

Col. (1), (2) Group Nr. and identification.

(3) Approximate galactic coordinates of center.

(4) Approximate supergalactic coordinates of center.

(5) Apparent distance modulus μ and galactic absorption A_B in B system.

(6) Geometric distance modulus μ_0 and distance Δ in megaparsecs.

(7) Approximate major and minor diameters D x d of group in degrees and in megaparsecs.

(8) Mean corrected velocity V_0, number n of objects in mean, and average deviation A.D. from V_0.

(9) Components X, Y, Z of distance Δ in Mpc in supergalactic rectangular coordinate system.

TABLE 3. Brightest Members of the 14 Nearer Groups

NGC	TYPE	$\mathcal{L}$	B(0)	log D(0)	V_o	$-M_G$	log D(0)
			G1. SCULPTOR Group				
253	SAB(s)c	-	8.1	1.15	104	19.0	1.04
55	SB(s)m sp	-	8.2	1.16	97	18.9	1.05
300	SA(s)d	7	9.0	1.24	95	18.1	1.13
247	SAB(s)d	7	9.9	1.14	-129	17.2	1.03
7793	SA(s)dm	6½	10.3	0.85	197	16.8	0.74
45	SA(s)dm	8	11.2	0.87	489	15.9	0.76

Possible: I5332 + D1, D6 dwarfs?

NGC	TYPE	$\mathcal{L}$	B(0)	log D(0)	V_o	$-M_G$	log D(0)
			G2. M81 (N3031) Group				
3031	SA(s)ab	2	7.88	1.28	88	19.42	1.20
2403	SAB(s)cd	5	9.07	1.11	255	18.23	1.03
3034	I0 sp	-	9.57	0.74	322	17.73	0.66
4236	SB(s)dm	7	10.40	1.04	(186)	16.90	0.96
2976	SA(s)m p	-	11.09	0.50	169	16.21	0.42

Probable: 3077, I2574 = D81, A0814 (Ho II) = D50, A0936 (Ho I) = D63.

Possible: 2366 = D42, 2403, I342, N1569, 1560?, I356? (in UMa-Cam cloud)

Other possible (dwarfs): D33, 38, 39, 44, 51, 53, 66, 71, 77, 78, 80, 82, 86, 87, 122, 123, 165.

TABLE 3. Continued

G3. CVn I Cloud

4736	(R)SA(r)ab	3:	8.91	0.83	362	19.19	0.91
4258	SAB(s)bc	-	9.19	1.11	530	18.91	1.19
4826	(R)SA(rs)ab	-	9.60	0.77	352	18.50	0.85
4449	IB m	5	10.08	0.59	269	18.02	0.67
4214	IAB(s)m	6	10.38	0.79	311	17.72	0.87

Probable: 4136, 4150, 4244, 4395, I4182, A1157 = D105.

Other possible (dwarfs): D99, 125, 129, 126, 133, 141, 143, 154.

G4. N5128 Group

5236	SAB(s)c	-	8.22	1.00	335	20.16	1.15
5128	S0 p	-	8.38	1.01	271	20.18	1.19
4945	SB(s)cd:	-	9.48	0.90	-	19.30	1.12
5102	SA0^{-}	-	10.55	0.7[illegible]	348	17.90	0.85
5068	SAB(rs)cd	6	11.05	0.78	410	17.26	0.90
5253	IBm p	-	11.14	0.38	229	17.26	0.53

Possible dwarf: D174.

Table 3. Continued

G5. M101 (N5457) Group

5457	SAB(rs)cd	1	8.58	1.39	415	19.92	1.55
5194	SA(s)bc p	1	9.03	0.95	552	19.47	1.11
5055	SA(rs)bc	3	9.52	0.92	600	18.98	1.08
5195	I0 p	-	10.94	0.45	634	17.56	0.61
5585	SAB(s)d	7	11.66	0.64	467	16.84	0.80

Other members: 5204, 5474; probable: 5949.

Possible: 4605, 5907, 6503(?), A1353 (Ho IV), A1339 (Ho V).

Possible dwarfs: D167, 168, 169, 172, 175, 176, 177, 178, 181, 182, 183, 191, 193, 194, 205.

G6. N2841 Group

2841	SA(r)b	1	10.27	0.72	671	18.93	1.02
2681	SAB(rs)0/a	-	11.34	0.41	751	17.86	0.71
2541	SA(s)cd	7	12.14	0.68	-	17.06	0.98
2500	SB(rs)d	7	12.39	0.40	513	16.81	0.70
2552	SA(s)m?	8	(12.54)	0.39	-	16.66	0.69
2537	IB(s)m p	-	12.55	0.14	422	16.65	0.44

Possible: I2233 (Sd sp).

Possible (dwarfs): D40, 41, 43, 46, 48, 49, 52, 55, 59.

Table 3. Continued

G7. N1023 Group

1023	SB(rs)0⁻	-	10.65	0.55	729	18.95	0.93
925	SAB(s)d	4	10.96	0.83	718	18.64	1.21
891	SA(s)b:/	-	11.24	0.78	243	18.36	1.16
I239	SAB(rs)cd	-	12.14	0.61	-	17.46	0.99
1058	SA(rs)c	6:	12.26	0.38	583	17.34	0.76
1003	SA(s)cd	-	12.45	0.48	741	17.15	0.96

Possible: N672, I1727, N1156(?).

Probable (dwarfs): D24, 25.

Possible (dwarfs): D11, 17, 19, 22, 26.

G8. N2997 Group

2997	SAB(rs)c	-	(10.64)	0.80	-	19.36	1.26
2835	SB(rs)c	-	(11.38)	0.71	636	18.62	1.17
2784	SA(s)0°:	-	11.52	0.37	431	18.48	0.83
2848	SAB(s)c	7:	(12.55)	0.40	-	17.45	0.86
2763	SB(r)cd p	7:	12.91	0.31	-	17.09	0.77

Possible (dwarfs): D56, 57, 60, 61, 62.

Table 3. Continued

G9. M66 (N3627) Group

3627	SAB(s)b	3:	9.89	0.76	591	19.71	1.14
3628	Sbp	-	10.43	0.87	730	19.17	1.25
3623	SAB(rs)a	3:	10.51	0.70	640	19.09	1.08
3489	SAB(rs)0$^+$	-	11.24	0.29	570	18.36	0.67
3593	SA(s)0/a	5	11.91	0.47	429	17.69	0.85

Probable: 3596, 3666.

Possible: 3485, 3506, 3547; dwarfs: D89, 91, 108.

G10. CVn II Cloud

4631	SB(s)d	5:	10.04	0.87	646	19.56	1.27
4490	SB(s)d p	5	10.29	0.61	622	19.41	1.01
3675	SA(s)b	3	11.11	0.54	727	18.59	0.94
4656	SB(s)m p	-	11.18	0.76	775	18.52	1.16
4051	SAB(rs)bc	3	11.23	0.60	698	18.47	1.00

Other probable: 3769, 3769A, 3949, 4088, 4111, 4143, 4242, 4485, 4618, 4625, 4627, 4657.

Possible: 4025, 4288.

Table 3. Continued

G11. M96 (N3368) Group

3368	SAB(rs)ab	-	10.32	0.67	800	19.48	1.09
3351	SB(r)b	3	10.75	0.74	643	19.05	1.16
3379	$E^{+}1$	-	10.83	0.36	746	18.97	0.78
3384	$SB(s)0^{-}$	-	10.84	0.41	636	18.96	0.83
3377	E5-6	-	11.75	0.30	593	18.05	0.72

Other members: 3239, 3377A, 3412, 3447, 3447A.

Probable: 3299, 3300, 3306, 3346, 3357, 3419A.

Possible: 3433, 3444, 3466, 3506.

Possible dwarfs: D79, 88, 89, 90.

G12. N3184 Group

3184	SAB(rs)cd	3	10.59	0.80	418	19.51	1.29
3198	SB(rs)c	3	11.09	0.80	670	19.01	1.29
3432	SB(s)m sp	-	11.94	0.50	594	18.16	0.99
3319	SB(rs)cd	3	11.95	0.69	832	18.15	1.18

Table 3. Continued

G13. Coma I Cloud

4725	SAB(r)abp	1	10.21	0.89	1109	19.89	1.37
4559	SAB(rs)cd	4	10.56	0.82	852	19.54	1.30
4565	SA(s)b?	1:	10.61	0.84	1171	19.49	1.32
4414	SA(rs)c:	3:	11.21	0.41	720	18.89	0.89
4494	E1-2	-	11.31	0.28	1305	18.79	0.77

Other members: 4203, 4245, 4251, 4274, 4278, 4283, 4314, 4448, 4670, A1244.

Possible: 4062, 4146, 4286, 4359, 4375, I3330.

Possible (dwarfs): D101, 117, 131, 133, 143, 154.

G14. N6300 Group

6300	SB(r)b	-	11.54	0.49	1120	19.26	1.11
6221	SB(s)c	-	11.75	0.42	1281	19.40	1.11
6215	SA(s)c	-	12.06	0.24	1410	19.09	0.83
I4662A	S	-	-	0.14	-	-	0.72
6215A	S:	-	-	0.00	-	-	0.69

Possible: I4710, I4713, I4714.

Explanation of Columns

(1) NGC or other identification. (2) Revised type. (3) DDO Luminosity class. (4) Standard "face-on" magnitude B(0). (5) Standard "face-on" diameter D(0) (in min. of arc). (6) Corrected red shift (km/sec). (7) Absolute magnitude corresponding to B(0). (8) Log linear diameter corresponding to D(0) (in kiloparsecs).

TABLE 4. Brightest Members of 40 Nearby Groups

G15. Cetus I

NGC	TYPE	B(0)	V_o
N1068	Sb	9.81	1094
N 936	$S0^+$	11.28	1371
N1084	Sc	11.38	1448
N1087	Sc	11.74	1833
N1055	Sb	11.77	-

G16. N1566

NGC	TYPE	B(0)	V_o
N1566	Sbc	10.09	1173
N1553	$S0^\circ$	10.57	1033
N1549	E0	11.05	942
N1617	Sa	11.40	-
N1574	$S0^-$	11.62	667

G17. Ursa Major Z

NGC	TYPE	B(0)	V_o
N4151	Sab	11.48	989
N3941	$S0^\circ$	11.66	969
N4145	Sd	11.68	-
N4369	Sa	12.84	-
N3813	Sb	12.88	-

G18. Virgo I (S)

NGC	TYPE	B(0)	V_o
N4321	Sbc	10.26	1552
N4501	Sb	10.49	2056
N4254	Sc	10.52	2397
N4569	Sab	10.58	893
N4579	Sb	10.72	1680

G19. Virgo I (E)

NGC	TYPE	B(0)	V_o
N4472	E2	9.84	855
N4649	E2	10.30	1200
N4486	E0-1p	10.30	1187
N4382	$S0^+p$	10.43	712
N4374	E+1	10.82	878

G20. Virgo Y

NGC	TYPE	B(0)	V_o
N4697	E6	10.58	1176
N4699	Sb	10.60	1369
N4731	Scd	11.63	1305
N4856	S0/a	11.68	1095
N4939	Sbc	11.70	-

G21. N1433

NGC	TYPE	B(0)	V_o
N1433	Sa	10.90	787
N1512	$S0^+$	11.58	542
N1448	Scd	11.67	-
N1493	Scd	12.10	-
N1411	S0	12.16	-

G22. N1672

NGC	TYPE	B(0)	V_o
N1559	Scd	11.06	-
N1672	Sb	11.29	-
N1688	Sc	12.66	-
N1796	Sb	13.18	-
N1703	Sb	-	-

Table 4. Continued

G23. N3672

N3672	Sc	11.80	1845
N3892	$S0^{+}$	12.70	-
N3637	$S0^{o}$	13.01	-
N3865	-	13.07	-
N3818	E5	13.23	1320

G24. Ursa Major Y

N3776	Sc	11.09	998
N3583	Sb	12.20	-
N3614	Sc	12.42	-
N3415	?	12.98	-
N3478	?	13.04	-

G25. Virgo I (S')

N4535	Sc	10.90	1854
N4380	Sb:	12.37	-
N4469	S0/a	12.41	-
N4519	Sd	12.47	1125
N4424	Sa:	12.57	-

G26. Virgo X

N4303	Sbc	10.28	1559
N4636	$E^{+}0$-1	11.01	778
N4536	Sbc	11.21	1814
N4517	Scd:	11.43	1095
N4643	S0/a	11.64	1325

G27. Grus

N7552	Sab	11.44	1639
N7424	Scd	11.46	-
N7410	$S0^{+}$	11.61	1637
I5267	S0/a	11.65	1695
N7582	Sab	11.84	1428

G28. Ursa Major X

N3310	Sbc	11.20	1090
N3448	I0	12.42	-
N3549	Sc:	12.76	-
N3445	Sm	13.16	-
N3458	S0	13.26	-

G29. Virgo III

N5566	Sab	11.62	1581
N5746	Sb	11.81	1826
N5713	Sbcp	11.99	1930
N5701	S0/a	12.16	-
N5584	Scd	12.16	-

G30. N5866

N5866	$S0^{+}$	11.19	972
N5907	Sc:	11.40	725
N5879	Sbc:	12.32	1064
N5805	Sb	12.41	-
N5908	Sb	12.96	-

Table 4. Continued

G31. Eridanus

N1232	Sc	10.73	1734
N1398	Sab	10.73	1395
N1187	Sc	11.21	1491
N1300	Sbc	11.34	1565
N1407	E+0	11.43	1707

G32. Ursa Major I (S)

N3938	Sc	11.02	919
N3893	Sc:	11.10	1065
N4096	Sc	11.31	-
N4157	Sb:	11.80	-
N4217	Sb	11.81	-

G33. Cetus II

N 720	E5	11.47	1813
N 584	E4	11.71	1885
N 779	Sb	12.20	-
N 596	E0	12.31	2097
N 615	Sb	12.51	1991

G34. Ursa Major I (N)

N3992	Sbc	10.80	1147
N3953	Sbc	11.11	1041
N3631	Sc	11.27	1162
N3898	Sab	11.60	1135
N3718	Sap	11.72	1128

G35. Virgo V

N4546	SO^-	11.62	879
N4691	SO/a	11.81	-
N4487	Scd	11.82	-
N4593	Sb	11.87	-
N4504	Scd	12.01	-

G36. N2207

N2207	Sbc	11.54	2455
N2217	SO^+	11.69	1334
N2223	Sb	12.18	-
N2280	Scd	12.24	-
N2139	Scd	12.39	1691

G37. N5676

N5676	Sbc	11.87	2395
N5630	Sc	12.44	-
N5633	Sb	13.07	2484
N5689	SO/a	13.17	2355
I1029	S:	-	-

G38. N6876

N6943	Scd	12.32	-
I5052	Sd	12.47	-
N6876	E3	12.79	-
N6808	Sa	13.60	-

Table 4. Continued

G39. N134

N 134	Sb	11.22	1665
N 289	Sbc	11.92	1907
N 150	Sb	12.34	-
N 148	SO?	12.95	-
N 254	SO?	12.97	-

G40. N488

N 488	Sb	11.41	2284
N 474	SO°	12.51	2405
N 520	P	12.75	2320
N 521	Sbc	12.75	-
N 470	Sb	12.75	-

G41. N2768

N2768	$E^{+}6$	11.48	1495
N2805	Sd	11.95	2023
N2742	Sc:	12.41	-
N2880	SO^{-}	12.97	1614
N2654	Sa	13.05	1448

G42. N2964

N2859	SO^{+}	11.96	1649
N2964	Sbc	12.37	1284
N3003	Sbc	12.52	1429
N3032	SO°	12.86	1500
N3067	Sab	12.91	1[illegible]55

G43. N3396

N3430	Sc	12.39	1709
N3395	Scdp	12.46	1622
N3396	Imp	12.90	1611
N3427	Sb:	-	-
N3413	SO sp	-	-

G44. N3923

N3923	E4-5	11.40	1551
N4105	E3	12.10	1665
N3904	$E^{+}2-3$	12.43	1374
I 764	Sc:	12.44	-
N4106	SO^{+}	12.49	1948

G45. Pavo-Indus

N7213	Sa	11.57	1751
N7205	Sbc	11.70	1404
N7049	SO°	12.04	2153
N7083	Sbc	12.14	-
N7144		12.15	2085

[illegible]. Virgo W

N4261	[illegible]-3	11.84	2093
N4281	[illegible]$^{+}$	12.41	2492
N4273	Sc	12.51	2192
N4260	Sa	12.70	1827
N4235	Sa	12.86	-

Table 4. Continued

G47. N3190			
N3227	Sa	11.75	1005
N3190	Sap	12.20	1255
N3162	Sbc	12.30	1361
N3193	E2	12.37	1273
N3226	$E^{+}2p$	12.77	1232

G48. N3504			
N3504	Sab	11.80	1473
N3414	S0	12.23	1391
N3512	Sc	13.12	1449
N3418	$S0^{+}$	-	-
N3380	S	-	-

G49. N3607			
N3607	S0°	11.42	840
N3626	$S0^{+}$	12.11	1361
N3686	Scd	12.24	930
N3608	E2	12.31	1117
N3684	Sbc	12.63	1329

G50. N5846			
N5846	$E^{+}0-1$	11.76	1784
N5813	E1-2	12.09	1891
N5838	$S0^{-}$	12.14	1441
N5850	Sb	12.25	2385
N5806	Sb	12.70	1309

G51. N6643			
N6643	Sc	11.97	1790
N6217	Sbc	12.17	1616
N6340	S0/a	12.21	2351
N6412	Sc	12.62	1751
N6654	S0/a	12.80	2180

G52. N6861			
N6868	E2	12.31	2734
N6861	$S0^{-}$	12.43	-
A2021	S0:	12.49	-
N6902	S0/a	12.67	-
N6893	S0°	12.85	-

G53. Fornax I			
N1399	E0	11.15	1311
N1380	S0	11.30	1712
N1404	E1	11.34	1828
N1326	$S0^{+}$	11.75	-
N1350	Sbc	11.80	1657

G54. N3245			
N3245	S0°	12.04	1198
N3254	Sbc	12.41	1170
N3277	Sab	12.60	1399
N3274	-	13.12	-
N3245A	Sb	-	-

TABLE 5.

Frequency of Distance Moduli for 55 Nearby Groups*

μ_o	<26	26.0 26.9	27.0 27.9	28.0 28.9	29.0 29.4	29.5 29.9	30.0 30.4	30.5 30.9	31.0 31.2
n	1	1	2	3	3	4	7	18	16
$N=\sum n$	1	2	4	7	10	14	21	39	55

TABLE 6.

Frequency of Major Diameters of 55 Nearby Groups*

D(Mpc)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	Mean
38 Groups*	2	8	8	17	3	-	-	-		1.5
17 Clouds and Clusters	-	-	-	6	5	3	1	2		2.5

* Including Local Group

TABLE 7. Luminosity Function and Population Type Indices of 55 Nearby Groups

Group	N_{18}	N_{17*}	$\bar{t}$	Range	S_t	n
0 Local	2-3	3-4	+6.4	(+3, +9)	2.1	5
1 Scl	3	4	+7.3	(+5, +9)	1.0	6
2 Mdl	2	3	+4.6	(-1, +9)	3.7	5
3 CVn I	4	6	+5.6	(+2, +10)	3.5	5
4 5128	3	6	+3.3	(-4, +10)	4.7	6
5 M101	3	4	+4.0	(-1, +7)	2.0	5
6 2841	1	3	+5.8	(0, +10)	2.9	6
7 1023	2	4	+3.8	(-4, +7)	3.0	6
8 2997	3	5	+3.6	(-3, +6)	2.6	5
9 M66	3	4	+1.0	(-2, +3)	1.6	5
10 CVn II	5	11	+6.0	(+3, +9)	2.0	5
11 M96	2	5	-2.0	(-6, +3)	3.6	5
12 3184	4	4	+6.3	(+5, +9)	1.4	4
13 Coma I	10	12	+2.0	(-6, +5)	3.2	5
14 6300	3	(3)	(+4.3)	(+3, +5)	(0.9)	3
15 Cet I	10	(16)	+2.8	(-2, +5)	1.9	5
16 1566	9	(13)	-1.6	(-6, +4)	3.3	5
17 UMa I (Z)	3	(5)	+2.0	(-3, +7)	2.4	5
18 Virgo S	27	(45)	+3.4	(+2, +5)	0.9	5
19 Virgo E	32	(51)	-5.0	(-6, -2)	1.2	5
20 Virgo Y	16	(22)	+1.4	(-6, +6)	3.5	5
21 1433	8	(8)	+1.6	(-3, +6)	3.5	5
22 1672	3	(4)	+4.0	(+3, +6)	1.2	5
23 3672	2	(6)	-1.5	(-6, +5)	3.2	4
24 UMa I (Y)	3	(6)	(+4.3)	(+3, +5)	(0.9)	3
25 Virgo S'	5	(10)	+3.2	(0, +7)	2.2	5

* () where incomplete

Table 7. Continued

26 Virgo X	24	(37)	+1.8	(-5, +6)	3.4	5
27 Grus	17	(24)	+1.6	(-2, +6)	2.1	5
28 UMa I (X)	3	(6)	+2.8	(-3, +9)	3.8	5
29 Virgo III	15	(23)	+3.0	(+2, +6)	1.6	5
30 5866	5	(5)	+2.6	(-2, +5)	1.8	5
31 Eri	19	(24)	+2.2	(-5, +5)	3.0	5
32 UMa I (S)	15	(20)	+4.2	(+3, +5)	1.0	5
33 Cet II	6	(8)	-2.4	(-6, +3)	4.3	5
34 UMa I (N)	15	(18)	+3.2	(+1, +5)	1.4	5
35 Virgo V	9	(12)	+2.2	(-4, +6)	3.4	5
36 2207	6	(7)	+3.4	(-2, +6)	2.3	5
37 5676	3	(4)	+3.0	(0, +5)	1.2	4
38 6876	3	(4)	+2.0	(-6, +7)	4.5	4
39 134	(5)	(5)	+0.8	(-3, +4)	3.0	5
40 488	5	(6)	+1.8	(-3, +4)	2.3	4
41 2768	5	(6)	+0.8	(-5, +7)	4.2	5
42 2964	4	(8)	+1.0	(-3, +4)	2.8	5
43 3396	3	(3)	+4.2	(-3, +10)	3.4	5
44 3923	8	(8)	-2.8	(-6, +5)	3.4	5
45 Pavo-Indus	24	(24)	0.0	(-6, +4)	3.6	5
46 Virgo W	6	(14)	-0.2	(-6, +5)	3.1	5
47 3190	6	(8)	-1.0	(-6, +4)	3.6	5
48 3504	3	(3)	+0.5	(-3, +5)	3.0	4
49 3607	6	(10)	-0.2	(-6, +6)	4.2	5
50 5846	8	(1[illegible])	-1.8	(-6, +3)	3.8	5
51 6643	(5)	(5)	+2.8	(0, +5)	2.2	5
52 6861	9	(12)	-3.2	(-6, 0)	1.4	5
53 For I	15	(15)	-2.6	(-6, +4)	2.9	5
54 3245	4	(4)	+1.5	(-3, +4)	2.2	[illegible]

TABLE 8.

Average Statistical Masses of Nearby Groups and Clouds

Average	Nearer Groups	All Groups	Clouds	Clusters[¶]
Number of Groups	10	27	13	3
Velocity dispersion σ_v (km/sec)	100[†]	200	250	650:
Radius R* (Mpc)	0.4	0.4	0.6	0.6:
Total mass $\mathfrak{M}_T^*$ ($10^{11}\odot$)	40	160	480	3000:
Mass per galaxy $\mathfrak{M}_1^*$ ($10^{11}\odot$)[§]	2	5	3	12:
Density ρ* ($10^{-27}gcm^{-3}$)	2	5	3	24:

¶ Vir I (E), Vir I (S), For I

† Approx. corrected for observational errors

§ Assuming N_T = 10 N_{18} in first 5 magnitudes

[illegible] of Nearby Groups and Galaxies

SG latitude B		(0°, ±10°)	(0°, ±20°)	(0°, ±30°)	(0°, ±90°)
Local Group	N	0 (0%)	2 (20%)	4 (40%)	10
	S	4 (25%)	11 (69%)	12 (75%)	16
(Fig. 1)	N+S	4 (15%)	13 (50%)	16 (62%)	26
"Outstanding"	N	25 (69%)	30 (83%)	32 (89%)	36
galaxies	S	10 (42%)	18 (75%)	20 (83%)	24
(Fig. 7)	N+S	35 (58%)	48 (80%)	52 (87%)	60
Dwarf	N	85 (49%)	114 (66%)	146 (85%)	172
galaxies	S	16 (32%)	26 (52%)	38 (76%)	50
(Fig. 6)	N+S	101 (45%)	140 (63%)	184 (83%)	222
Nearer	N	6 (75%)	7 (88%)	8 (100%)	8
groups	S	5 (55%)	6 (66%)	8 (89%)	9
(Fig. 3)	N+S	11 (59%)	13 (77%)	16 (94%)	17 *
Nearby	N	5 (36%)	6 (43%)	11 (78%)	14
groups	S	12 (38%)	18 (56%)	24 (75%)	32
(Fig. 4)	N+S	17 (37%)	24 (52%)	35 (76%)	46 †
All Nearby	N	11 (50%)	13 (59%)	19 (86%)	22
groups	S	17 (41%)	24 (59%)	32 (78%)	41
	N+S	28 (45%)	37 (59%)	51 (81%)	63
Random ¶		21%	41%	59%	100%

* Counting UMa-Cam Cloud as 3 groups, Coma I as 2 groups.

† Counting Cet I, Cet II, Vir III, Pavo-Indus as 2 groups each, Eri I as 3 groups.

¶ Including allowance for effect of galactic absorption.

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CAPTIONS TO FIGURES

Fig. 1. Apparent distribution of Local Group members in supergalactic coordinates.

Fig. 2. Map of Local Group projected onto supergalactic plane.

Fig. 3. Apparent distribution of nearer group ($\mu_0 \leq 30.0$) in supergalactic coordinates.

Fig. 4. Apparent distribution of nearby groups ($30.2 \leq \mu_0 \leq 31.2$) in supergalactic coordinates.

Fig. 5. Cumulative frequency distribution of distance moduli of nearby groups (including Local Group).

Fig. 6. Apparent distribution of DDO dwarf galaxies in supergalactic coordinates.

Fig. 7. Apparent distribution of outstanding galaxies in supergalactic coordinates.

Fig. 8. Space distribution of nearby groups projected onto the supergalactic (Z, Y) plane.

Fig. 9. Space distribution of nearby groups with $|Z| < 5$ Mpc projected onto the supergalactic (X, Y) plane.

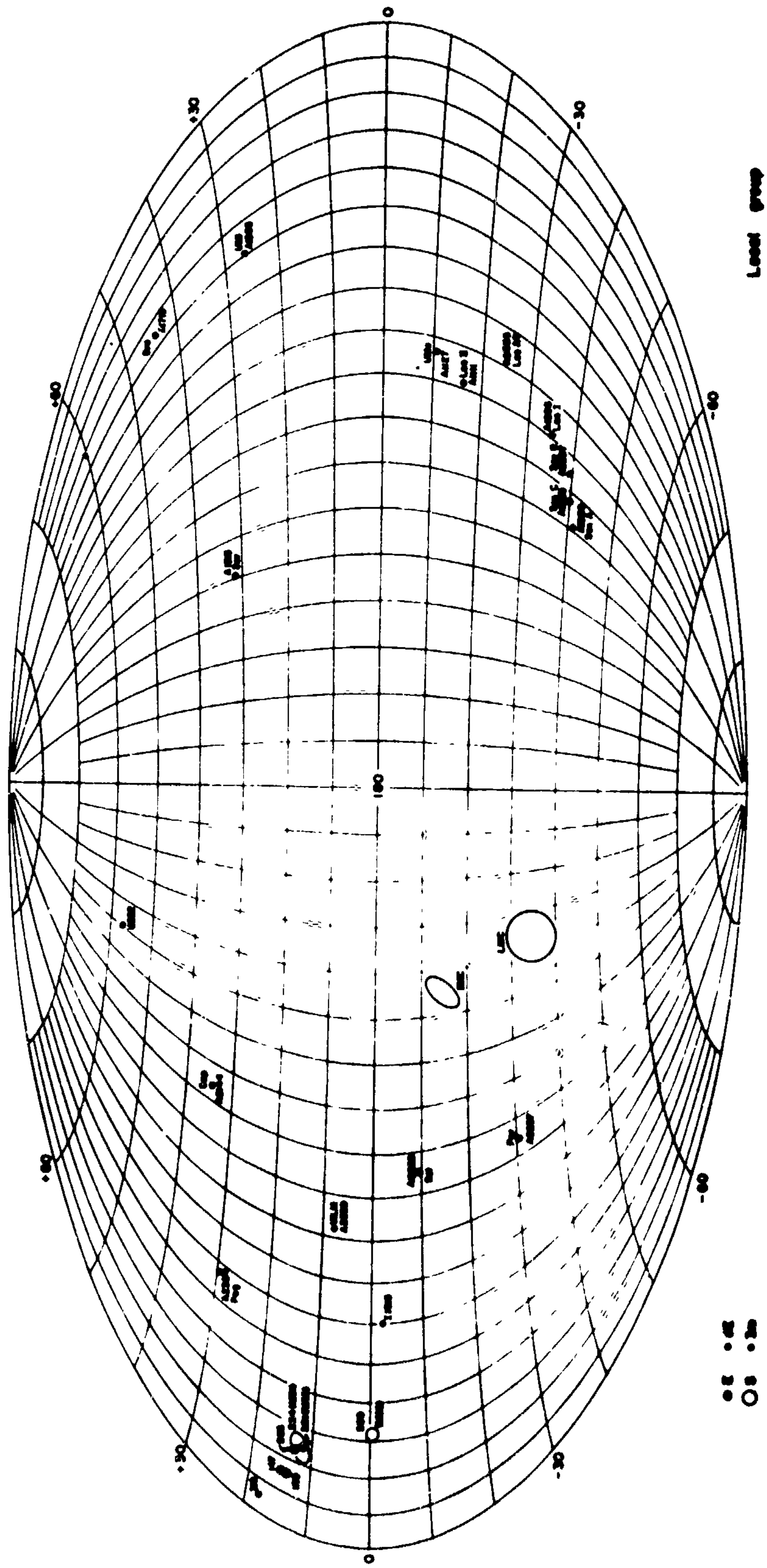


Fig. 1

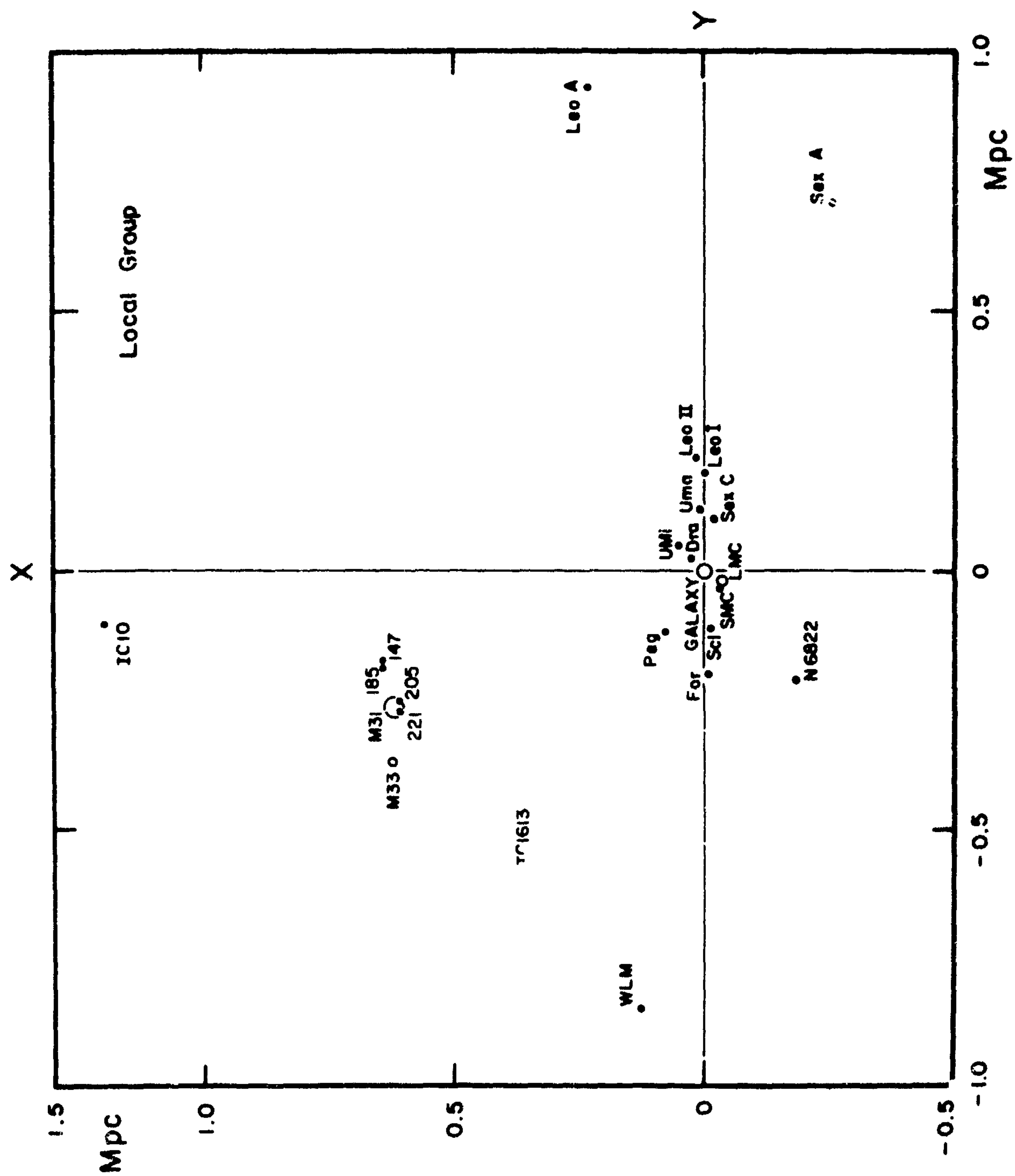

Local Group
Mpc
Mpc
X
Y
1.5
1.0
0.5
0
-0.5
-1.0
Leo A
Sex A
Leo II
Leo I
Uma
Sex C
UMi
Dra
GALAXY
LMC
SMC
IC10
Peg
Scl
For
N6822
185
147
205
M31
221
M33
WLM

Fig. 2

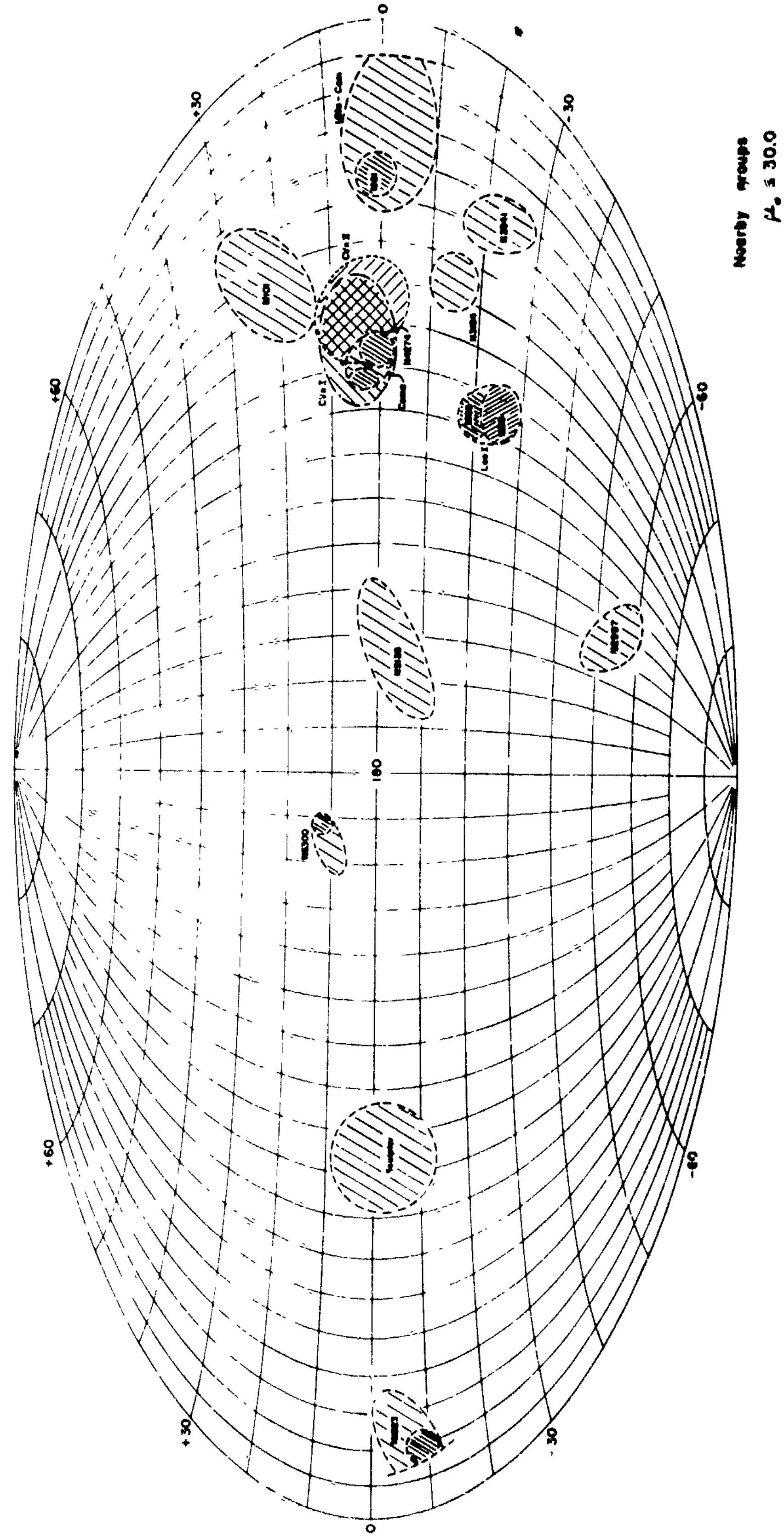
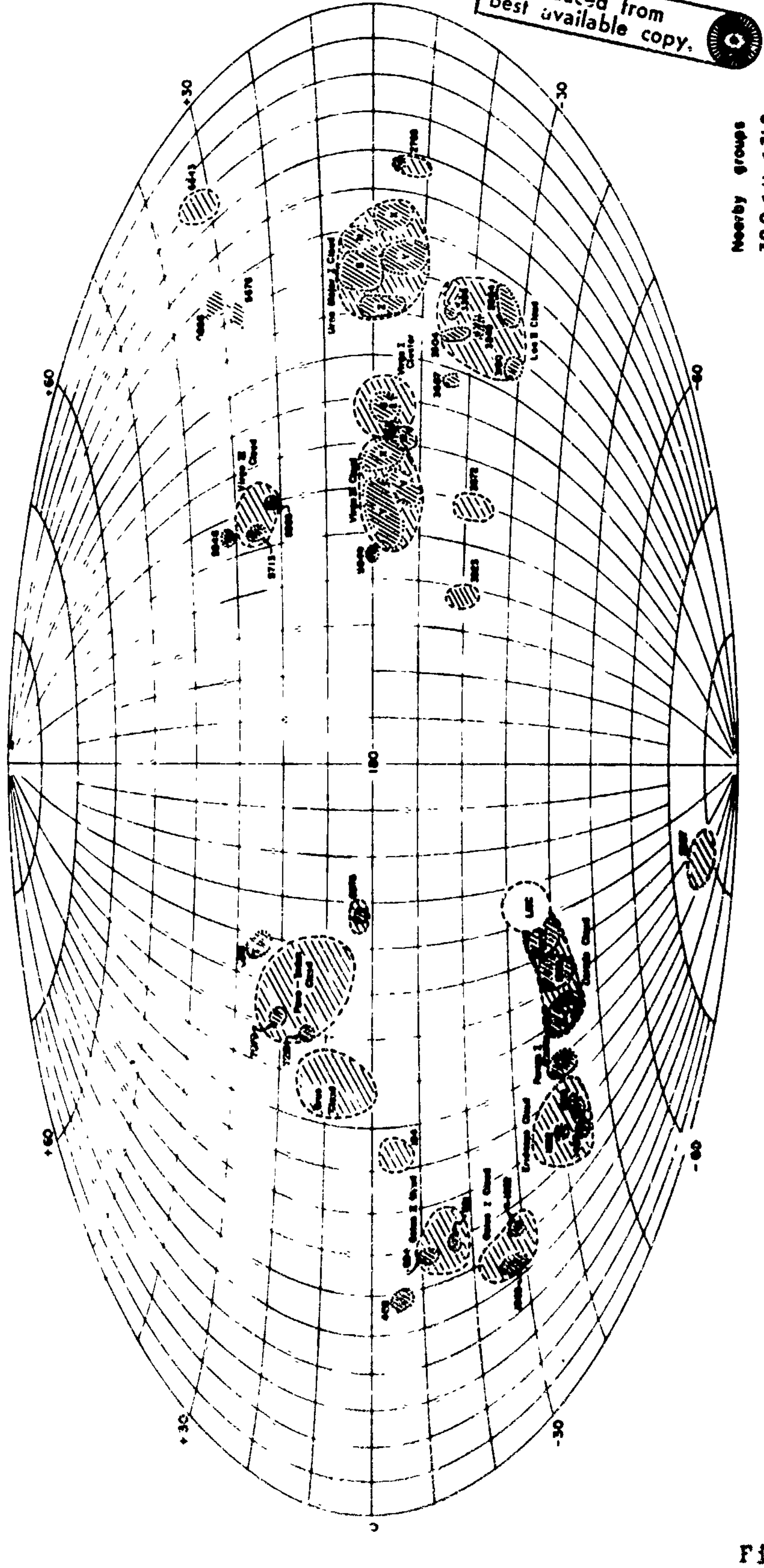


Fig. 3



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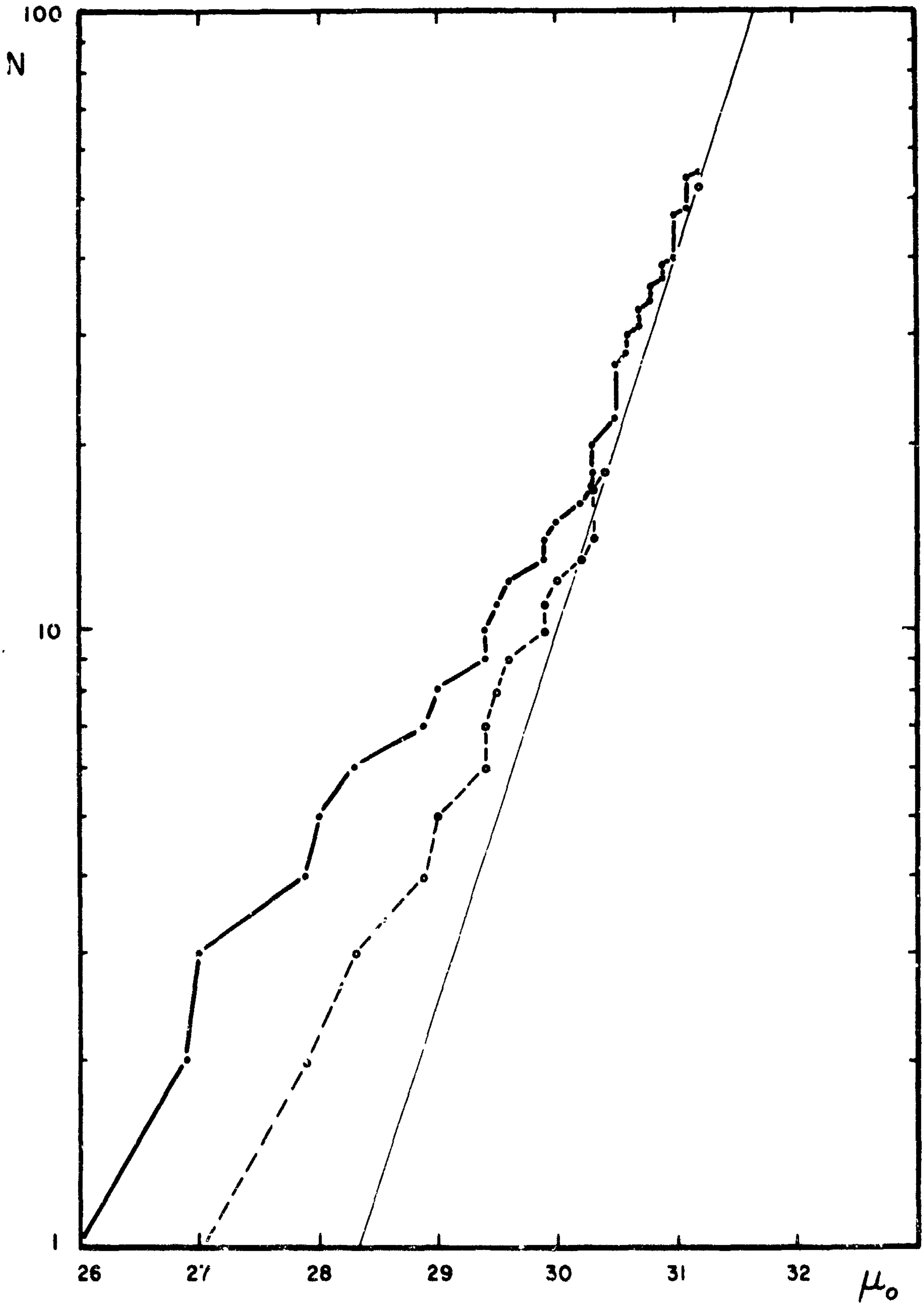

Fig. 5

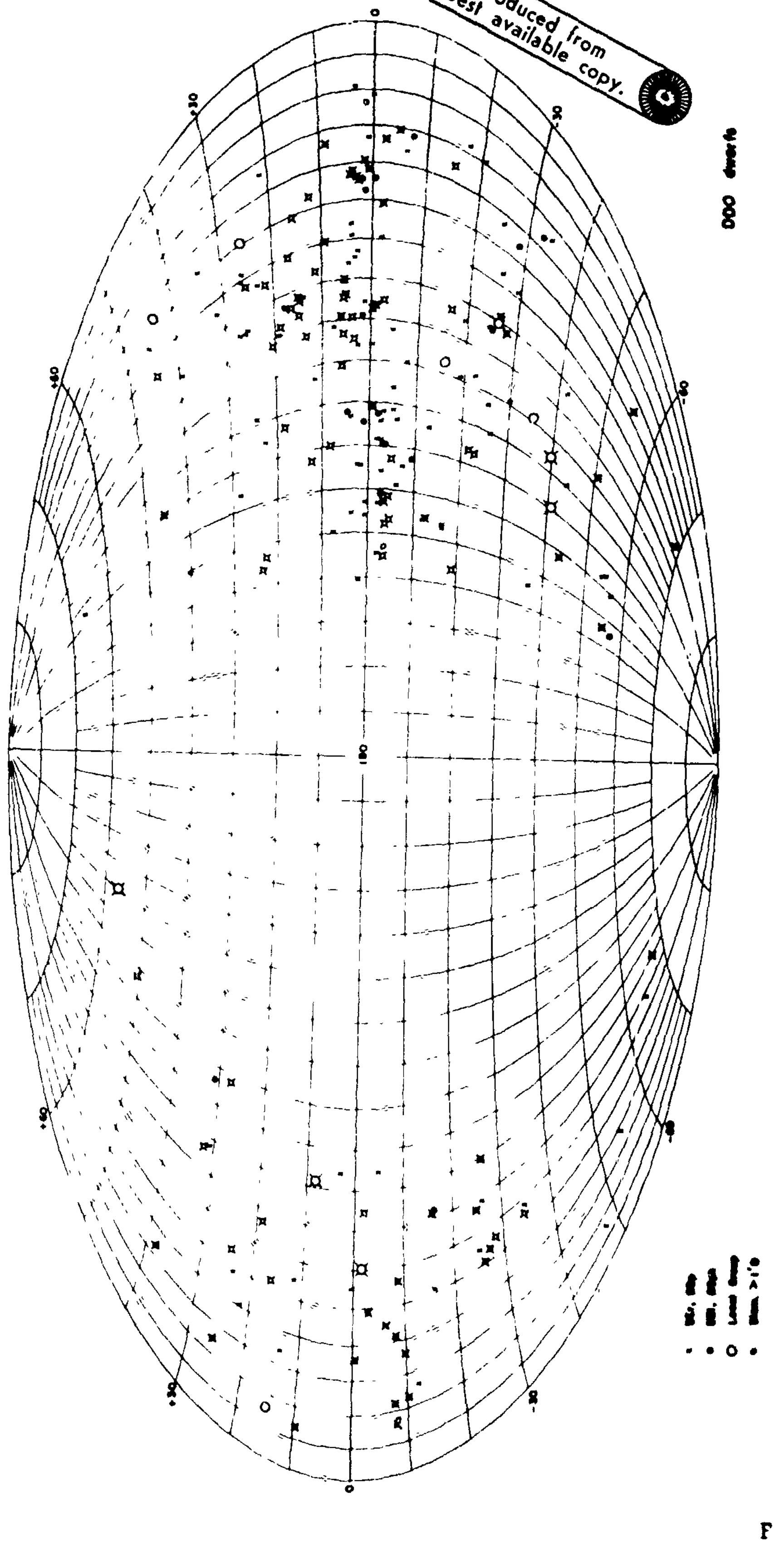

Fig. 6

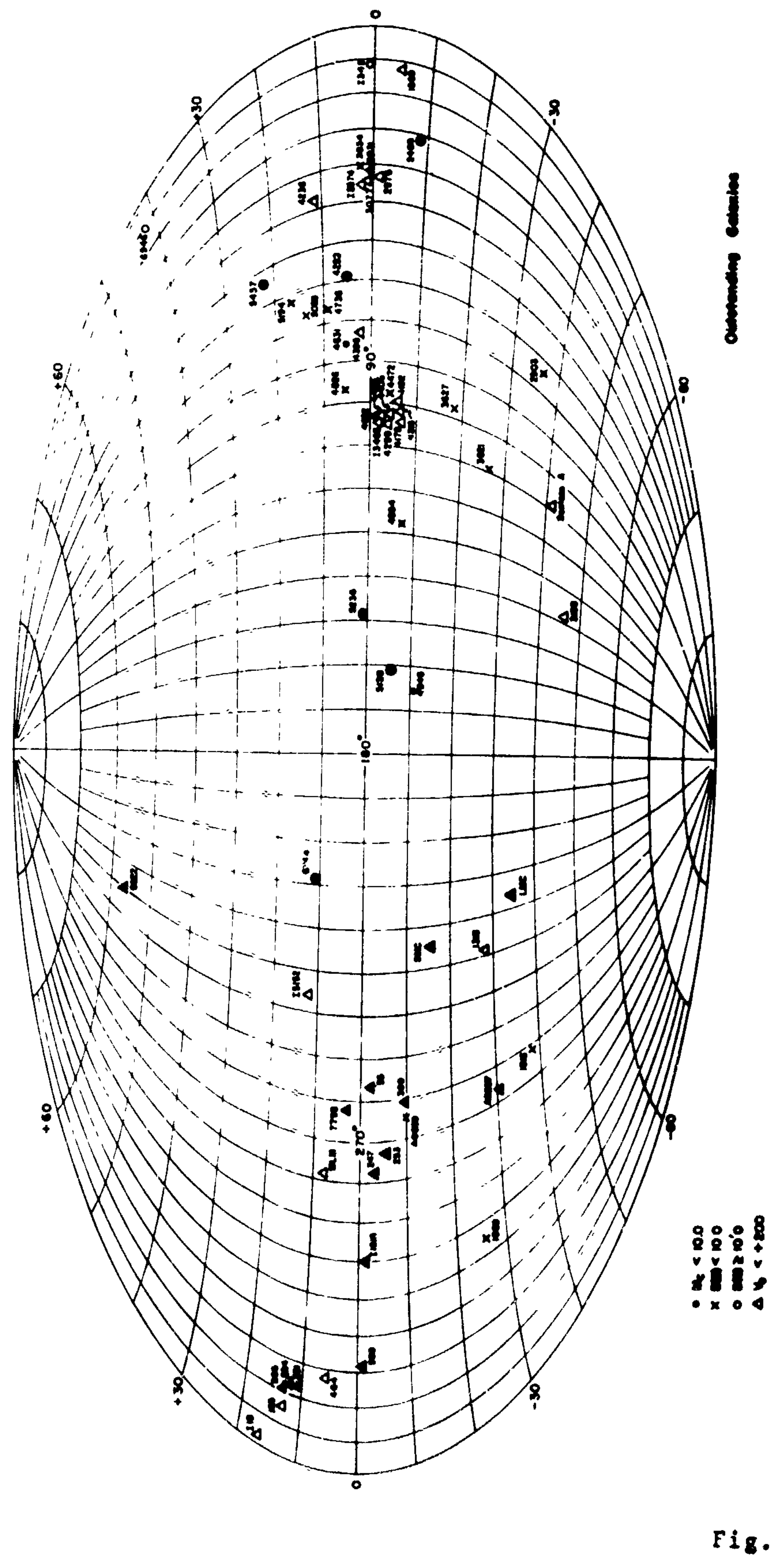

Fig. 7

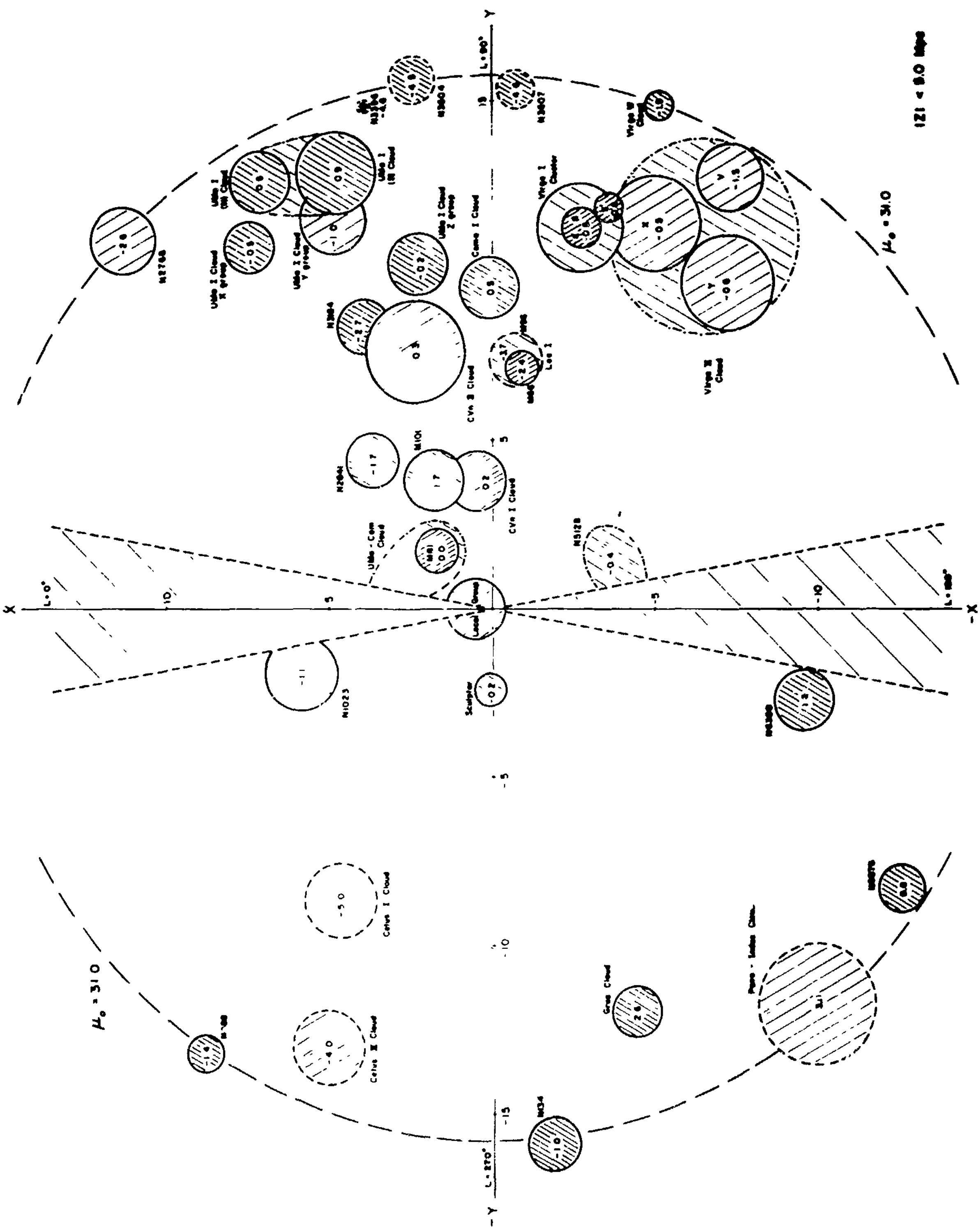

Fig. 9